JOURNAL

VOLUME 11, NUMBER 4 • APRIL, 1955

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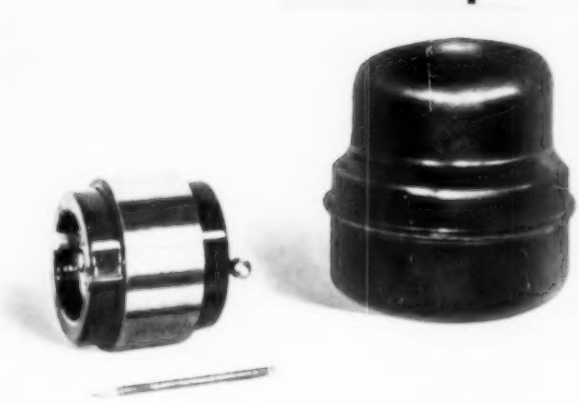
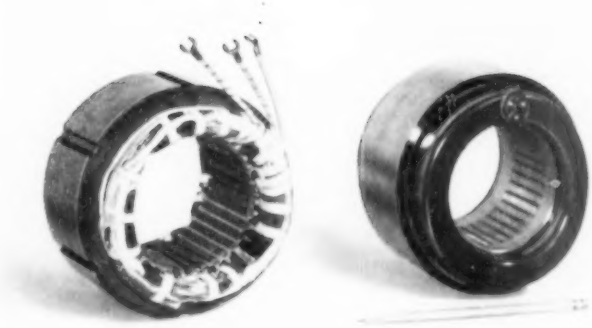


New Compressor (left) takes only 27% of the space of a conventional unit (right). It has only 10% as many parts, weighs 58% less, and will cost much less to produce.

Assembled stator (left). Finished stator (right) has been potted with Epon resin formulation. New compressor was developed by Wetmore Hodges and Associates, Redwood City, California.



Why not combine the pump and the motor? Put a gear pump *inside* the motor stator, encase the stator in plastic, and you can build an entire motor-compressor in the space occupied by a conventional motor alone!

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The Pacific Northwest section is one of three new sections which recently joined SPE. Photo shows L. E. Tallman of Seattle receiving the Section Charter from John LaBelle and Joe Healey in ceremonies held at the SPE 11th Annual Conference last January.

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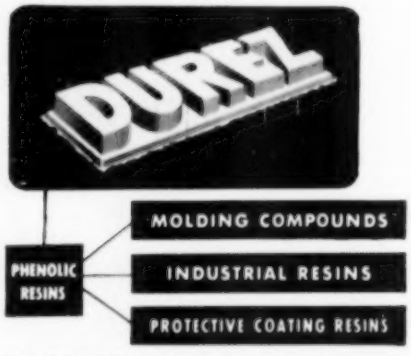

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Book Reviews . . . .

INDUSTRIAL DESIGN

Harold Van Doren. Published 1954 by McGraw-Hill Book Co., New York. 379 pages, $6.50.

In his most recent book, one of America's foremost industrial designers gives his readers a broad insight into the whole field of industrial design. While the book is directed towards the design student, it also serves as excellent reference material for any person interested in industrial design. Here Van Doren methodically attacks design problems in non-technical, clearly understood language and arrives at a concrete solution to the problems.

The engineers and draftsmen who have certain types of design problems to solve; the commercial artists and advertising men who wish some insight into the mechanics of product design; and the business executive who wants to bring about a proper relationship between his own staff and the professionals they engage to perform design services will find this book to be invaluable.

Starting with a brief history of recognized industrial design, Van Doren elaborates upon the designer's place in industry. For the student preparing for a design career he clearly explains industrial design from incubation through its numerous stages until it is ready for actual production.

The text is liberally sprinkled with illustrations, not only of his own talents but with those of other qualified industrial designers.

Author Van Doren defines modern industrial design as "the practice of analyzing, creating, and developing products for mass manufacture. Its goal is to achieve forms which are assured of acceptance before extensive capital investment has been made, and which can be manufactured at a price permitting wide distribution and reasonable profits." In one brief paragraph he has clearly interpreted the pursuits of the profession.

As an industrial designer, I wholeheartedly endorse and recommend "Industrial Design" to any person who wants a better understanding of the profession as a whole.

J. O. Reinecke

GLASS REINFORCED PLASTICS

Edited by Phillip A. Morgan, M.A. (1954-256 pp.) Illife and Sons, Ltd.; London S. A. Publishers, Philosophical Library, Inc., New York, New York. (Published, U.S.A.) $10.00.

This book presents a well organized study of fibre glass materials, resins, glass-resin combinations and end properties, design techniques and requirements, fabricating techniques and special field of application as represented by "tubes and rods" — "aircraft components" — "electrical laminates" — "boats" — "automotive and transport." The final chapter is devoted to miscellaneous and potential applications.

Individual chapter preparation is by officials of British resins and fibre glass producers, fabricators and members of "British Plastics" editorial staff. Mr. Morgan is editor of the latter publication. Materials and practices represent those of the U.S.A. as well as those of the British Isles. Well detailed illustrations, charts and property tables accompany each phase under discussion.

Particular emphasis is given to the forms of glass fibre constructions (cloth, roving and mat). Similarly dealt with are resins (polyester, phenolic, silicone, epoxide, melamine and furane) polyester control additives, and

(Please turn to page 24)

Across the Editor's Desk . . . .

Too Rich!

• Ever hear the phrase "an embarrassment of riches" and wonder how on earth such a thing could be? Your editor knows all too well the answer to that one, since he, —or more accurately the SPE Journal—is suffering such embarrassment right now. Actually, too. The fact is that we have more *good* articles than we can print, and we've been crowding "Plastics Around the World" to get space for articles, so that we have a stack of abstracts for which there is no room. Our first duty is to the section news, so we get it all in — at least *almost*, though a couple of nice reports got left out this time. Your editor is thinking of growing a beard in hopes he can pass through certain cities unrecognized!

• Many good conference papers have to appear elsewhere, so keep your eyes on Plastics Technology, Materials and Methods, Electrical Manufacturing and Modern Plastics for articles from the Conference!

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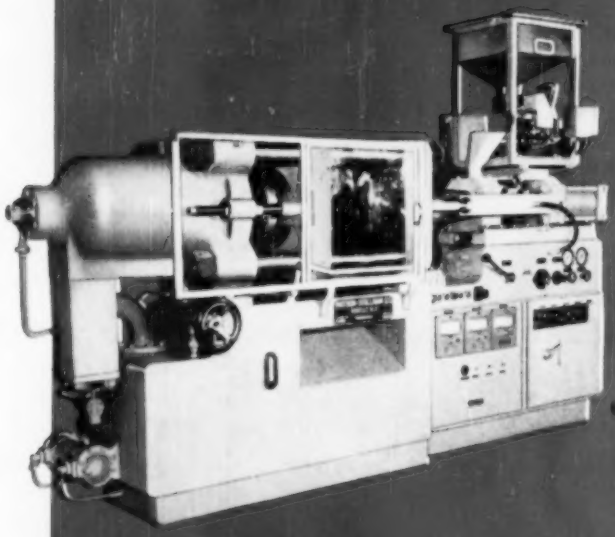

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YOUR NATIONAL OFFICE

"The objects of the Society shall be to promote in all lawful ways the arts, sciences, standards and engineering practices connected with the use of plastics."

New York's Vocational Education

This is the story of how the New York Section of the Society placed plastics in the curriculum of the Machine & Metal Trades Vocational High School in New York City. It is written by Mr. Harold Schwartz, former President, New York Section, who headed this cooperative effort of the N.Y. Board of Education and the Society.

Every Section of the Society in a major plastics area can obtain similar educational service for its industrial community.

• • • • • •

Early in the 1940's a survey of the plastics industry was made to ascertain possible avenues of training for Vocational High School students in the New York City area, industrial acceptance of such trainees, employment possibilities and the anticipated growth of the industry. As a direct result of this survey the establishment of a course in "Plastics" was approved by the Advisory Board for Vocational and Extension Education* on March 16, 1942 by the Board of Superintendents on March 15, 1943 and by the Board of Education on March 24, 1943.

The Advisory Board set up the first Plastics Educational Commission as part of its organization under the combined chairmanship of Mr. George K. Scribner, of the Boonton Molding Co. and Mr. William T. Cruse, Executive Vice President of the Society of Plastics Industry. This Commission of the Advisory Board held several meetings but due to the war conditions prevailing at the time, no specific recommendations were made. It was more or less agreed to postpone further action on the establishment of a course in plastics.

No action was taken until 1950 when Mr. Harold B. Schwartz of Empire Brushes, Inc. met with Mrs. Betty Howley Donnelly, the Executive Secretary of the Advisory Board, and outlined a training program suggested by the Board of Directors of the New York Section of the Society of Plastics Engineers. The Advisory Board re-organized the Plastics Educational Commission in 1950. The first meeting of the re-organized Commission was held on February 28, 1951 at which time Mr. Harold Schwartz was appointed Chairman with Mr. Richard Thews of Monsanto Chemical Co. as Co-Chairman.

All members of the original Commission were contacted. New members were appointed and several committees, namely the survey, curriculum, finance, equipment and public relations, immediately went into action.

In 1952, under the new Commission, a most thorough and exacting survey of all phases of the plastics industry in the Metropolitan area was made. The Board of Directors of the New York Section of the Society of Plastics Engineers, many of whom are members of the Commission, undertook this survey as their special project, carrying it to completion by a well organized mail, telephone and personal follow-up campaign.

The findings of this second survey substantiated the recommendations of the Commission that the plastics field offered fine opportunities for our vocationally trained high school graduates. The survey also emphasized the commission's feelings that the industry would assist the Board of Education financially and materially.

Given the impetus of these findings the Curriculum Committee set up a proposed course outline. When this outline was tentatively approved the Equipment Committee went into action to provide the necessary machinery and tools to carry out the aims of the proposed course.

While many of the companies were exceedingly generous in donating machinery, tools, small molds, machine parts, finishing and assembly equipment, all of which were checked, repaired and overhauled under the supervision of Mr. Bruno Wessinger of Wess Plastic Molds, Chairman of the Equipment Committee, it was still necessary to start a financial campaign to purchase equipment not readily available. Again the Board of Directors of the New York Section of the Society of Plastic Engineers stepped into the breach by establishing an Educational Fund for this purpose, under the direction of Mr. Palmer Humphrey of the R. C. Molding Co., to which most of the members of the plastics industry generously made financial contributions.

Mr. Saul Blitz of Tico Plastics, Chairman of the Material Recruitment Committee was very successful in obtaining the proper materials and supplies required to fulfill the objectives of the curriculum.

While these committees were hard at work, the Student Recruitment Committee under the direction of Mr. William Lewi of Dusal Tool & Mold Co. and Mr. Herb Weber of Rotuba Extruders, arranged many special, well planned, graphic meetings with Junior High School groups and their Guidance Counselors to acquaint them with the work of the proposed plastic course.

At the same time Mr. Herb Weber succeeded Mr. R. Thews as Co-Chairman as Mr. Thews was transferred out of the area due to his promotion at Monsanto Chemical Co.

In briefing the above activities it is hard to comprehend the terrific amount of man hours given by the Commission members. Since the first meeting on February 28, 1951 until December 2, 1954 there were twelve regular commission meetings, two special meetings with the Junior High School and 8 B school Counsellors, three school exhibits and recruitment programs and last but certainly not least, the meetings of the special working committees. Much credit must be given to Mrs. Donnelly and her very able assistants, Mr. Geo. Kleher and Mr. Wm. Hugwalker, who did most of the leg work and worked very hard in co-ordinating the activities of all these committees.

Finally, all the Committee work was completed and the program was pronounced ready for trial. The Board of Education, through Dr. C. Frederick Pertsch, Superintendent in Charge of High Schools, approved the selection of Machine and Metal Trades High School for the establishment of the course. Again problems arose. Physical alterations had to be made to run equipment,—equipment had to be set up,—the Principal of the Machine & Metal Trades High School, Mr. John Mangione, had to organize the faculty, have the students screened and selected and dovetail the course into the overall school program. Again

(please turn to page 8)

Your National Office . . .

(continued from page 7)

the printed facts only take minutes to read but all of these activities were time consuming.

Early in September of 1954, the first class in "Plastics" was under way. This class started with approximately twenty five selected senior students who will spend all their school shop hours in this, their final year in the new "Plastics" shop.

As the course meshes into gear in the ensuing years it is hoped that the "Plastics Course" will eventually be a full three year Vocational High School program.

Realizing that many changes will be necessary, the Commission is constantly working with the school in an effort to improve the course. The Curriculum Committee, under the Chairmanship of Mr. Irvin Rubin of Robinson Plastics, Inc. is presently engaged in re-evaluating the curriculum to determine what changes, if any, can be suggested that will be of utmost benefit to the students and to industry.

Also, a special committee, under the Chairmanship of Mr. Arthur GeWertz is now working on a plan whereby the first graduates of the course in June 1955 will be placed in our industry to their best advantage.

At the last meeting of the Commission it was recommended that an award for scholarship be presented at each graduation, to the best student in the "Plastics Course," as our reward for a job well done.

As for future expansion, we have already received requests for evening classes for workers presently employed in our industry. A special committee will, when the demand is great enough, set up such a program. It is the fond hope of the commission that eventually a Vocational High School completely devoted to the Plastics Industry will be established in New York City, which could readily serve as a focal point for the many activities in our vast and ever-expanding industry.

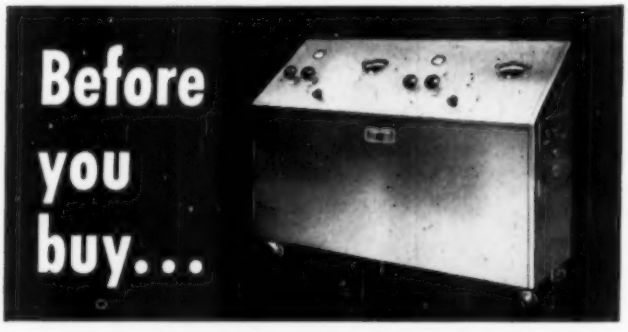
Finally may we state that our primary objective has been reached, but only through the untiring efforts of the entire Commission who gave up untold hours both from their business and personal lives. While some of the original members, due to the demands of business have had to resign, their work in this venture will always be remembered.

**The Advisory Board for Vocational and Extension Education is a state mandatory unit appointed by the Board of Education to advise them on all matters pertaining to Vocational Education.*

Plastic Fair Dates Changed

The dates for the World Plastics Fair and Trade Exposition have been changed from April to October according to an announcement made late last month by exposition director, Philip M. Kent. New dates will be October 5 through 9. The Exposition hall will still be the National Guard Armory in Los Angeles.

The surprise announcement came after a series of meetings held by the exposition directors and SPI officials attending the Reinforced Plastics Conference in Los Angeles early last month. The new dates will provide more time for plastics manufacturers, machinery firms and resin suppliers to ready exhibits for the exposition. Dates set up will not be in conflict with any other major meetings of the SPI or SPE or any of their regional chapters.



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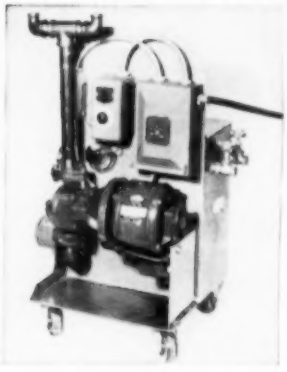

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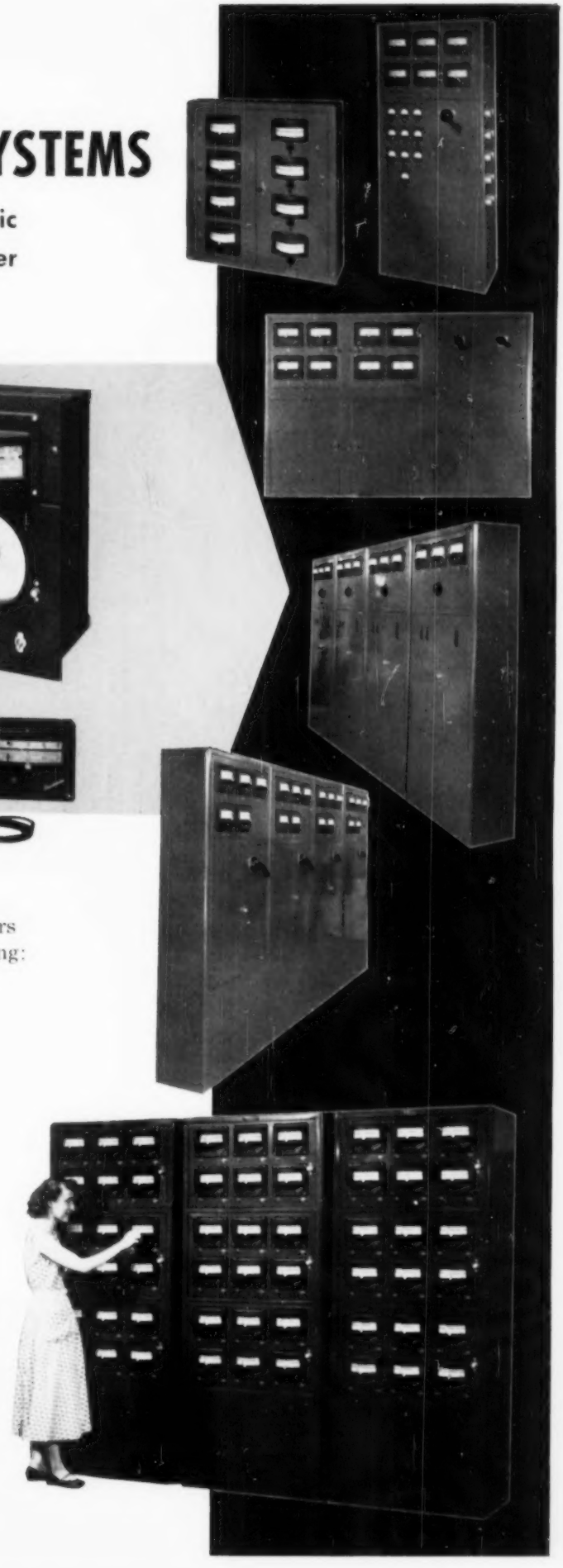

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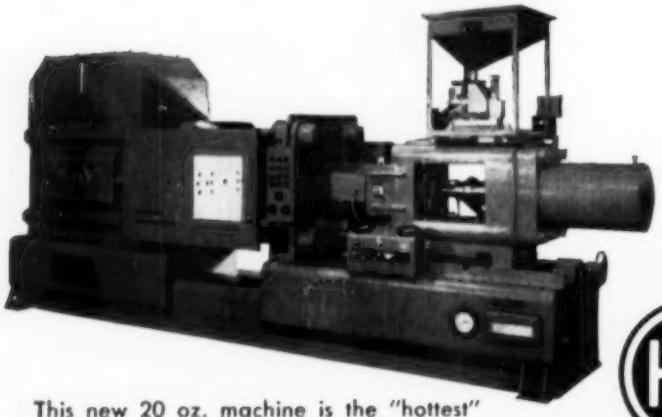

This new 20 oz. machine is the "hottest" production unit on the market. Completely new with plenty of daylight and stroke, large platens, large heating chamber, high speed injection. The 50 H.P. hydraulic unit, with sub-plate mounted valves, is extremely quiet. Weigh feeder is standard equipment. Write for complete details.

Yes, a radio cabinet is one of the injection molder's toughest jobs! That's why General Industries, Sylvania, Santay, General Electric and other leading cabinet makers use H-P-Ms. They have plenty of daylight and stroke for deep parts . . . extra plasticizing capacity . . . high speed injection . . . large platens to accommodate big molds.

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Coefficients of sliding friction of filled and unfilled "Teflon" have been measured at temperatures from 25 to 300°C in an apparatus designed to distribute the normal force evenly over the test sample. The values found for the coefficient of friction were lower than values previously reported (2, 3). This may be due to the surface finish of the metal slider or to the fact that our apparatus measures values of the coefficient of friction which represent the limit of Shooter's relation: coefficient of friction = shear strength/yield pressure.

It has been known for some time that "Teflon" tetrafluoroethylene resin has unusually good antifrictional properties. Values near 0.04 have been reported for the dynamic coefficient of friction of polytetrafluoroethylene (2, 3) sliding on steel or on itself. Shooter found the coefficient of friction to be independent of temperature up to 200°C. He also found, as we did, that the coefficient of friction varies with the normal force, being higher at low normal forces. Our measurements extend the temperature to 300°C and the normal forces to 4000 pounds. The design of our apparatus permits a better measure of normal force than does Shooter's (2) or Bowers', et al (3) as discussed below.

Because of current interest in compositions of "Teflon" and inert fillers, the coefficient of friction of several such mixtures has been measured.

The Sliding Friction of Teflon

John B. Thompson
George C. Turrell[1]
Bernd W. Sandt

E. I. du Pont de Nemours and Co., Inc.
Wilmington Delaware

APPARATUS: Operation and Theory

The coefficient of friction data were obtained with the apparatus shown in Figure 1. The polymer samples were placed in the circular groove in the aluminum block A. The steel B in contact with the sample C was "Elastuff" A-2. For most of the measurements the steel was polished on a metallographic polishing wheel to an R.M.S. finish of about 2 micro inches. A few measurements were made with the steel polished with #600 Carborundum. The steel was in the form of a ring ¼-inch wide and two inches outside diameter. Normal forces up to 4000 pounds (2910 psi) were provided by a hydraulic press through a self-aligning thrust bearing which rested on plate D. A layer of "Transite" E helped to insulate plate B when measurements were made at high temperatures.

A torque was exerted on the system by hand through a 15 inch lever arm F. Two Baldwin SR-4 strain gages were attached to the arm to indicate the tangential force. The gages formed two arms of a Wheatstone bridge connected to a recording potentiometer. The gages were calibrated by hanging weights on the lever arm at frequent intervals while measurements were being made. The calibration did not change during the experiments. The torque on the system, in inch-pounds, is 15 x pounds force on the lever. The torque, as measured by the strain gages, is related to the frictional force at the surface of the polymer by the expression.

$$\mu = \frac{42T}{37N}$$

where μ is the coefficient of friction, **T** is the torque in inch-pounds, and **N** is the normal force in pounds. This relation is derived as follows: from the definition of coefficient of friction we have

$$F = \mu N \qquad (1)$$

where **F** is the frictional force.

To relate the measured torque **T** to the frictional force **F**, consider a circular increment of the steel ring of width **dr**, to which is applied an increment of torque dT. Assume that μ is independent of speed, and hence of the radius **r**, and that the normal force is evenly distributed over the sample. The increment dN of the normal force acting on the circular element dr is therefore the total normal force multiplied by the ratio (area of increment)/(total area), or

$$dN = N \frac{2\pi r\, dr}{\pi (r_2^2 - r_1^2)} \qquad (2)$$

where r_1 and r_2 are the inner and outer radii of the steel ring. From (1), the turning force on the element dr is

$$dF = \mu dN$$

The torque due to this force is given by force x distance:

$$rdF = r\,\mu dN = dT$$

Putting in the expression for dN from (2), we have

$$dT = \mu r N \frac{2rdr}{(r_2^2 - r_1^2)}$$

The total torque for the whole ring is the integral between

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(1) *Present address, Bell Telephone Laboratories, Murray Hill, N. J.*
(2) *a. K. V. Shooter and P. H. Thomas, Research 2, 533 (1949)*
b. K. V. Shooter, Proc. Roy. Soc. (A) 212, 488 (1952)
c. K. V. Shooter and D. Tabor, Proc. Phys. Soc. 65B, 661 (1952)
(3) *R. C. Bowers, W. C. Clinton and W. A. Zisman, J. Applied Physics 24, 1066 (1953); Modern Plastics 31, Number 6, 131, (February 1954)*

the limits r_2 and r_1:

$$T = \mu \frac{2N}{(r_2^2 - r_1^2)} \int r^2 dr$$

$$= \frac{2\mu N (r_2^3 - r_1^3)}{3 (r_2^2 - r_1^2)}$$

Putting in our values $r_2 = 1$ inch, $r_1 = \frac{3}{4}$ inch, we have

$$T = \frac{37 \mu N}{42}$$

$$\text{or } \mu = \frac{42T}{37N}$$

An indication of the amount of friction introduced by the thrust bearing was obtained by substituting another thrust bearing for the polymer test pieces: the coefficient of friction of the two bearings was about 0.0003, which is negligible.

The assumptions in the derivation of the formula above, namely, that μ is independent of speed and that the normal force is evenly distributed, require comment. The values reported here were measured at very low speeds, about 1.5 rpm. At ½ rpm, which was as slow as we could turn the lever by hand without having it stop now and then, the same values were obtained. At speeds of about 10 rpm the value of μ may be slightly higher, but not by much more than the experimental error. For our apparatus, μ is independent of velocity. Shooter found no variation in μ at linear speeds of 0.01 to 1.0 cm/sec (2a).

With deformable plastics such as "Teflon" and polyethylene the normal force is more uniformly distributed in our apparatus than in that used by Shooter and by Bowers, who studied friction effects by measuring the force required to move a steel or plastic hemisphere across a plastic or steel plate. With their method, the plastic is deformed in a very complicated way, and the normal force exerted by the hemisphere varies from zero to a maximum. Shooter discusses the problems involved with this method of measurement, including the elastic recovery of the plastic after the hemisphere has passed over the sample. It would be of interest to repeat his experiments, using a freely rolling sphere in place of the sliding hemisphere, in an effort to separate the frictional effects from the effects of plastoelastic deformation of the sample.

RESULTS AND DISCUSSIONS

The following results were obtained for the coefficient of friction against micropolished steel:

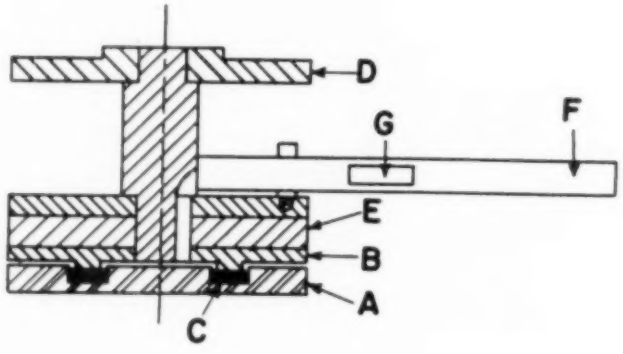
TABLE 1. Friction Test Results

Sample			Coefficient Friction
Unfilled "Teflon", dry [a]			0.016 ±10–15%
Unfilled "Teflon", lubricated			
Silicone Oil, DC 1107			0.006
Fluorocarbon Oil, FCX 331			0.010
Filled Compositions	Weight %	Volume %	
MoS_2 [b]	10	4.8	0.016
MoS_2	30	16.4	0.026
TiO_2 [c]	10	5.5	0.013
Asbestos [d]	10	10	0.014
Asbestos	30	30	0.030
Coke Flour [e]	10	10.9	0.017
Coke Flour	20	21.6	0.023
Coke Flour	30	32	0.027
Graphite [f]	30	29.4	0.031
Copper Powder [g]	50	19.8	0.017
Coarse Copper Powder	50	19.8	0.057
Polyethylene			0.09
Polychlorotrifluoroethylene			0.16

a. Unfilled "Teflon" ⅛" commercially molded sheeting
b. MoS_2 "Molykote" Type M (Alpha Corp.)
c. TiO_2 "Ti-Pure" LW titanium dioxide pigment (anatase) (Pigments Dept., E. I. du Pont de Nemours & Co., Inc.)
d. Asbestos Powminco Grade 60
e. Coke Flour G.C. 95 Calcined Petroleum Coke Flour National Carbon Division, UCC
f. Graphite "Acheson" GP-38 National Carbon Division, UCC (98.5% passes 200 mesh)
g. Copper Powder Grade MD 151, Metals Disintegrating Company, Elizabeth, New Jersey (60-75% passes 325 mesh)

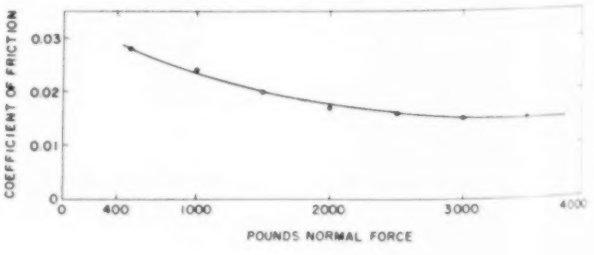
These are all limiting values measured at normal forces greater than 2000 pounds. At lower forces, higher and less reproducible values were obtained. The variation of coefficient of friction with normal force is shown in Figure 2, in which the data for unfilled "Teflon" are given. The curve is typical for all materials studied, showing that μ drops at high loads. Shooter found this to be the case for spheres of polytetrafluoroethylene sliding on steel plates, and the reverse for steel spheres sliding on polytetrafluorothylene sheets (2c). The deviation from theory in the latter case is accounted for by Shooter's "plowing

(please turn to page 38)



← Figure 1. Test Apparatus

Figure 2. Friction vs. Load for Teflon



Process Capability Analysis

Leonard A. Seder

Quality Control Consultant
Malden, Massachusetts

Is S.Q.C. worth money to you in your plant? Is your molding process giving you the best results of which it is capable? Process capability analysis can answer these questions.

This article is the eighth in the series "Statistical Quality Control for the Plastics Molder" written by the S.Q.C. committee of SPE under the chairmanship of L. M. Debing.

SOONER OR LATER, the management of every company comes face to face with the question: "How far is it sensible to go in improving quality?" Granted that further improvement is possible, they ask, how do we know that the value gained will be worth the cost of achieving the improvement?

No one can properly challenge management's right to raise this question, for it is fundamental that any activity in industry which is to be taken seriously must pay its way in increased revenue or lower costs. At the same time, no one who has followed the progress of quality control in industry for the past dozen years can have any serious doubt that investment in quality improvement is one of the most lucrative investments that his company can make.

Whatever may have been the "right" level of quality for maximum return a dozen years ago, the accumulating evidence from thousands of companies in all kinds of industries continues to indicate that it is no longer "right" today. Ever since the tools of Statistical Quality Control began to gain widespread acceptance, it became abundantly clear that, in them, management had found the sought-for means to realize the unheard of rate of return of 100%, 500% and even 1000% on its invested dollar.

Thus, the general proposition is essentially undebatable that the cost of quality improvement through modern quality control methods is well worth the savings it creates in scrap, repairs, rework, sorting inspection, customer returns and complaints. However, the question of the cost vs. the value of quality improvement may still properly be raised with respect to any specific company, or with respect to any particular line of product, or with respect to any particular machine or process. Indeed, it is the question that the Quality Control Engineer must constantly raise himself if he is to continue to retain his enviable position in industry.

Specific means exist with which to answer the question, whether applied to a company, a line of product, a machine or a process. All of them depend ultimately on being able to answer the more specific questions: "Is the process (or processes) doing as well as can be expected quality-wise? Is further uniformity of product quality economically attainable?" The method for obtaining valid answers to these questions is usually known as "Process Capability Analysis" (PCA) and it embodies several of the specific statistical techniques already discussed in this series of articles as well as some additional ones. It is the object of this article to discuss the methodology of the Process Capability Analysis and to illustrate its application particularly, although not exclusively, to the plastics molding process. It is assumed that the reader has already become familiar with the subject matter in the preceding articles, especially those by Fay, Young and Kudlock, and Dague and Hinchen.

ELEMENTS OF CAPABILITY ANALYSIS

In order to determine whether the degree of uniformity of a particular quality characteristic from a given process may be economically improved, five separate pieces of information are necessary.

1 A statement of the specifications for that quality characteristic which the product is expected to meet.
2 A measure of the "centering," or point on the measurement scale at which the process is aimed.
3 A measure of the total variability experienced in the process over a period of time.
4 A measure of the natural or inherent variability of the process (or, more accurately, the "instantaneous degree of reproducibility" of the process).
5 Revelation of the nature of the causes of any discrepancies between 3 and 4 and an estimate of the cost of eliminating these causes.

With these facts at hand, it becomes possible to make rational and accurate decisions as to the required action in a given situation. The first step is the derivation of these judgments from the above facts:

A Judgment as to whether the process is now meeting the specifications, by comparison of 1 with the composite of 2 and 3.
B Judgment as to whether the specifications can be met, or more nearly met, by a shift in the centering of the process, again by comparison of 1 with the composite of 2 and 3.
C Judgment as to whether the process is basically capable of meeting the specifications, by comparison of 1 with 4.
D Judgment as to whether it is economically feasible to eliminate (or sufficiently reduce) any causes of excess variability revealed in 5 to enable the

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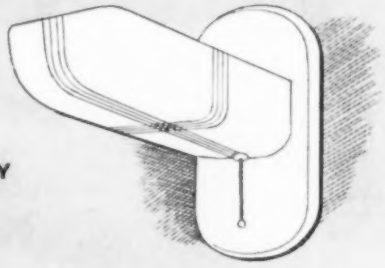

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process to meet, or more nearly meet the specifications.

These judgments may then be converted into the indicated actions, as follows:

I NO ACTION is needed if the process is meeting the specifications (other than action to insure that this desirable situation is maintained).

II ACTION TO SHIFT THE "AIM" of the process if it **can** but **does not** meet the specifications, whenever such a shift will enable specifications to be met, or more nearly met.

III ACTION TO REDUCE THE EXCESS VARIABILITY is needed if the process **can** but **does not** meet the specifications, whenever the cost of the action is worth the savings it affords in scrap, rework, inspection, customer returns, or other cost of defects.

IV ACTION TO REVISE THE SPECIFICATIONS is needed if the process **can** but **does not** meet the specifications, whenever the cost of reducing the excess variability would exceed the value derived therefrom.

V ACTION TO CHANGE THE PROCESS* or REVISE THE SPECIFICATIONS is needed if the process **cannot** meet the specifications.

VI RESIGNATION TO THE LOSSES and sorting costs of the process is the only evident answer if the specifications cannot be revised nor the process economically changed.

From this concise and possibly oversimplified statement of the elements of a Process Analysis, it may be seen that such an analysis can logically be regarded as a basic technique of scientific management. It is a rational, objective method of arriving at decision relative to the uniformity of product in the same sense that time study and job evaluation provide bases for decisions on wage rates or that methods analysis provides facts for decisions on tools, fixtures, workplace layout, etc.

Like these other techniques of scientific management, it has some limitations in precision; it is not entirely absolute and the exercise of some judgment is inevitably involved. However, much progress has been made in the last few years toward standardizing the analytical methods and minimizing the amount of judgment to be exercised.

One of the strong evidences of the objectivity of the Process Capability Analysis is the fact that comparison of data of numerous independent observers on the same types of processes shows good agreement. In some industries, compilations of the capabilities of various machines under various conditions have been made from the data of different analysts (3). As further application of the PCA method is made in the plastics industry, it is not at all visionary to foresee similar tables of the capabilities of various preforming presses with varying tablet sizes, of various types and sizes of injection and compression molding presses, and of various types of hand and automatic finishing processes.

Meanwhile, progressive plastics firms are making their own compilations of the capabilities of their own machines. Aside from the opportunity to confirm the fact that the capability of a given machine under given conditions is a basic property of the machine, the uses of such compilations of capability data are numerous:

1 They enable the purchaser of equipment to compare actual performances with manufacturer's claims. (Indeed, when employed by the equipment manufacturer, they offer a sounder basis for making such claims.)

2 They assist in discovering whether any individual machines are so poor in performance as to require extensive maintenance.

3 They furnish a rational basis for a review of specifications from both the molder's and customer's viewpoint.

4 They assist in the engineering planning task of choosing between the several methods of molding. (Actually, molding engineers have long considered the capability of the molding process as one of the elements in such decisions; however, PCA enables them to be much more precise in this connection.)

5 They assist in the production planning task of allocating jobs to specific presses of a given type. The fussy jobs can be routed to the most capable machines.

MAKING A SIMPLE CAPABILITY ANALYSIS

The making of a simple capability analysis does not involve any new statistical methods beyond those already covered in these articles. It is perhaps the particular **analytical** use of the methods, as distinguished from the **control** use during production, that constitutes a Process Capability Analysis.

In order to determine the measures previously listed as **2, 3, 4** and **5** under "Elements of Capability Analysis," we must concern ourselves with evaluating these four statistical properties of the process:

1 Its **centering,** or location on the measurement scale of the quality characteristic.

2 Its **spread,** or variability which exists among pieces produced by the process over a period of time.

3 Its **capability** or **variability** which exists among successive pieces produced by the process.

4 Its **stability,** or the extent to which the centering and capability are subject to change of any kind with time. A stable process is one which is said to be "in statistical control."

The most effective method of evaluating these properties is by means of a combination of the $\overline{X}$ and R chart and the frequency distribution. Successive pieces are taken from the process over a period of time and the $\overline{X}$ and R chart is plotted with the control limits. (See "The Concept of Control Charts," by Dague and Hinchen, for the detailed computations.) Then all of the individual measurements are tallied as a frequency distribution. The evaluation next proceeds as shown in the following table:

Evaluation of Centering, Spread, Capability and Stability

To Evaluate:	**Compute:**
Centering	$\overline{\overline{X}}$—The grand average of all the readings from either the $\overline{X}$ chart or the histogram.
Spread	6σ—six times the standard deviation of the values of the histogram.
Capability	$6\overline{R}/d_2$ — six times the average range of the control chart divided by the factor d_2.
Stability	Control limits for $\overline{X}$ and R. The process is unstable if more than 0 in 25 or 1 in 35 points are outside of these limits.

If the process is found to be stable, then the Spread will be found to be statistically identical* to the Capa-

* *By "change the process" is meant the substitution of a different process or basic alteration in the existing one, as, for example, by changing the order of operations, adding or omitting operations, retooling, machine overhauling, developing more capable equipment, or any other method of reducing the "instantaneous degree of reproducibility" of the process.*

bility, and it may be concluded that improved uniformity of product is not attainable without changing the process. However, if the process is already meeting the specifications, or the centering can be shifted so as to meet the specifications, then improved uniformity is not necessary. Figure 1 illustrates the three usual situations in this case and the indicated actions.

If the process is found to be unstable, then the Spread will be greater than the Capability and several possibilities exist: 1 In spite of the instability and larger-than-necessary Spread, the process may still be meeting the specifications or its centering may be able to be shifted so as to meet specifications; **2** the larger-than-necessary Spread may make it impossible for the process to meet the specifications; or **3** even though the cause of the instability were diagnosed and corrected, the Capability may be too poor to meet the specifications. Figure 1 also shows these situations and the indicated actions.

LIMITATIONS OF THE SIMPLE CAPABILITY ANALYSIS

The foregoing exposition of the Process Capability Analysis has been called "simple" because it involves certain limiting assumptions about the nature of the process being studied: To be specific, it has assumed:

1 That any effects of **time,** as measured by the Stability, will be apparent in the space of time over which the control chart was drawn. Since such charts are usually taken over a fairly short time, the longer term effects of time may not be reflected in the analysis.

2 That all the product goes through the same physical path, or **stream,** during the process. This assumption excludes such multi-stream processes as multi-cavity molding equipment, multi-head drill presses, multi-operator filing, etc. where the product diverges into parallel paths during the operation.

3 That a single measurement on any one piece properly represents the value of the quality characteristic on that piece. This assumption excludes situations in which:

a. There is a systematic difference in the measurement depending on the exact position or location on the piece where the measurement is made. This is called **within-piece** or **positional** variability and finds expression in the common terms: taper, out-of-roundness, out-of-parallelism, camber, off-centrality, eccentricity, bell-mouth, etc. Oftentimes these are present and cannot be omitted from the analysis.

b. There is a random difference in the measurement such that repeated readings yield a variety of results. This is **error of measurement;** it is obviously present to some extent in every measurement ever made. The simple PCA has assumed that it is small enough to be negligible in comparison with the quality characteristic being measured and thus excludes situations in which the error of measurement is a sizeable portion of the Process Spread.

4 That the distribution of the quality characteristics may be represented by the normal distribution. This assumption is implicit in the use of 6σ and $6\bar{R}/d_2$ since only in the normal distribution is it true that virtually all (actually 99.7%) of the distribution will be included within the range $\bar{X}-3\sigma'$ to $\bar{X}+3\sigma'$. This assumption excludes situations in which the basic process distribution is definitely skewed or excessively peaked or has some other non-normal shape.

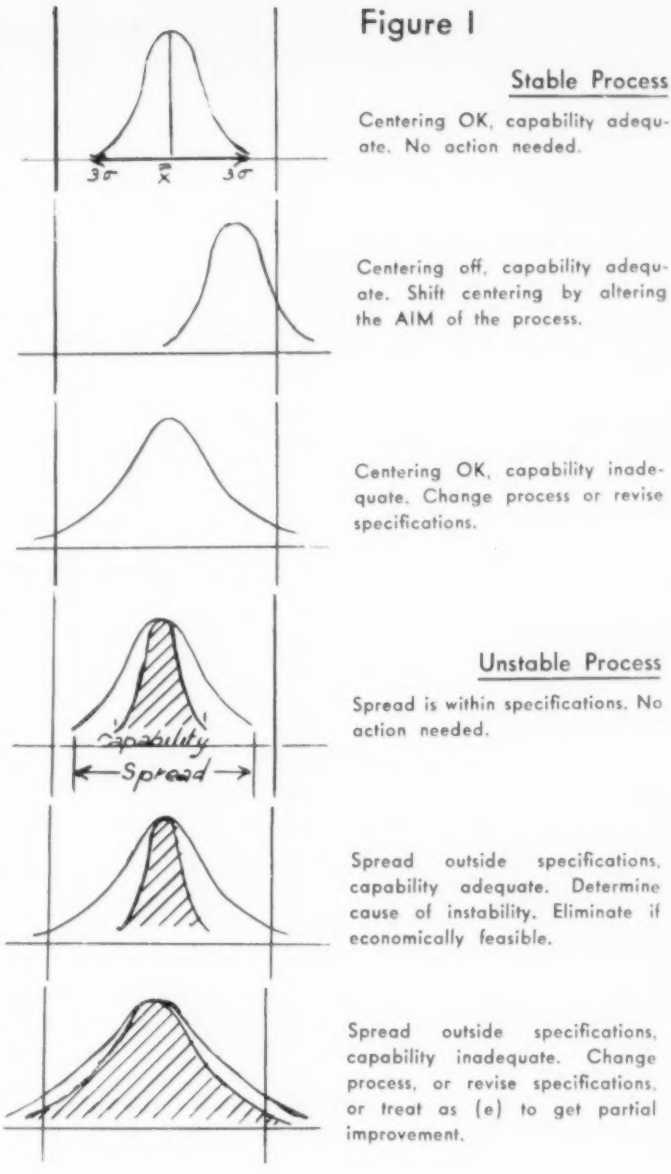


Figure 1

Stable Process

Centering OK, capability adequate. No action needed.

Centering off, capability adequate. Shift centering by altering the AIM of the process.

Centering OK, capability inadequate. Change process or revise specifications.

Unstable Process

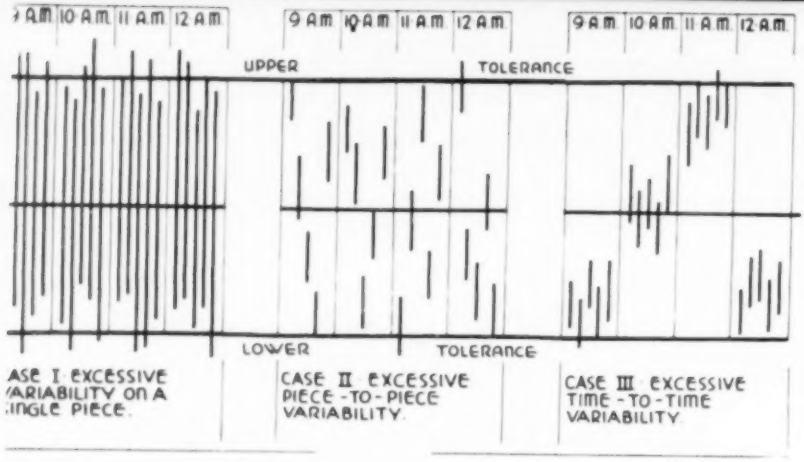
Spread is within specifications. No action needed.

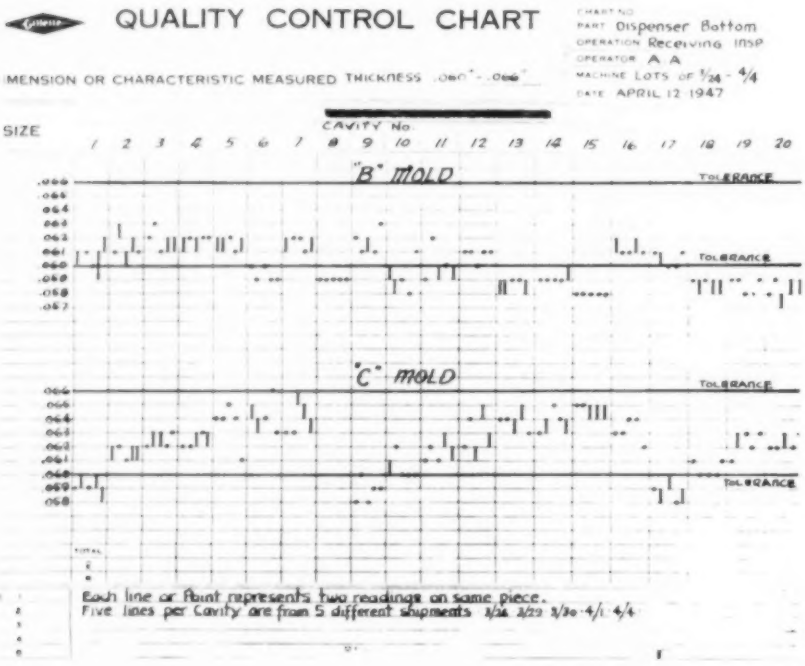
Spread outside specifications, capability adequate. Determine cause of instability. Eliminate if economically feasible.

Spread outside specifications, capability inadequate. Change process, or revise specifications, or treat as (e) to get partial improvement.

It should be clear from the above list of exclusions, that the simple PCA has definite limitations for universal application to all processes. The assumption of normality (#4) is, fortunately, not a serious handicap since the vast majority of industrial processes may be adequately approximated by the normal law. Also, the long-term time effects (#1) if they exist, may be encompassed by simply lengthening the time span of the measurements. However, the exclusion of multi-stream processes (#2) within-piece variability (#3a) and error of measurement (#3b) is a more serious limitation. Many industrial processes utilize multi-stream operations to speed up output per man-hour. (Consider, for example, the widespread use of multi-cavity molding equipment.) The within-piece variation is not infrequently a major problem. Moreover, while available measuring devices generally possess satisfactory accuracy for rigid bodies, such as molded parts, error of measurement often be-

"Statistically identical" means that the two measures have the same "expected" value; in any given set of data, they may differ slightly because of the random errors of estimation involved in the two formulae.




QUALITY CONTROL CHART
CHART NO.
PART Dispenser Bottom
OPERATION Receiving Insp
OPERATOR A A
MACHINE LOTS OF 1/24 - 4/4
DATE APRIL 12 1947
MENSION OR CHARACTERISTIC MEASURED THICKNESS .060"-.066"
SIZE
CAVITY No.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
"B" MOLD
TOLERANCE
TOLERANCE
"C" MOLD
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TOLERANCE
Each line or Point represents two readings on same piece.
Five lines per Cavity are from 5 different shipments 1/24 3/22 3/30 4/1 4/4

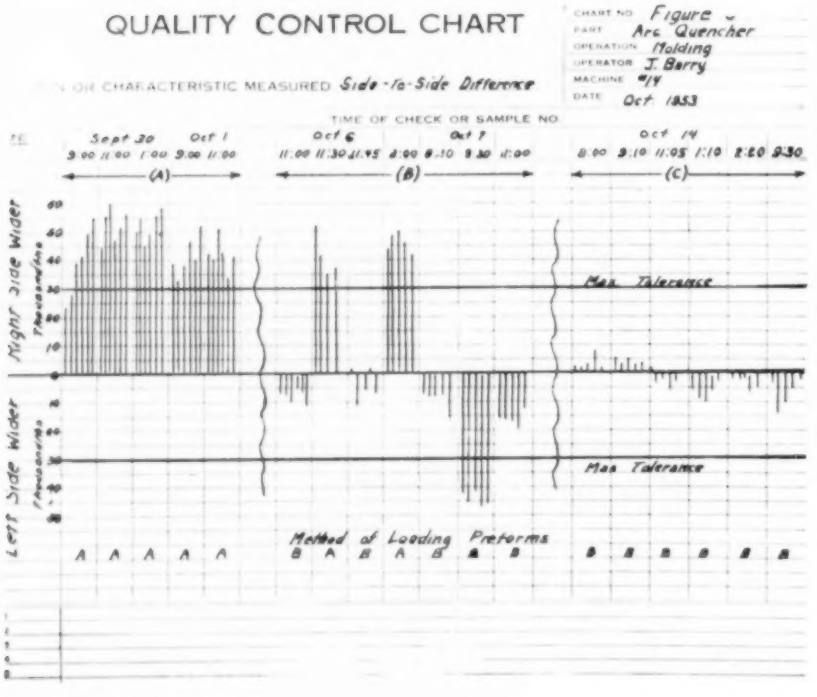


Figure 2 (top) A Multi-Vari chart showing "within-piece" variability. Each line is the sum of several length measurements. Figure 3 (middle) Multi-Vari chart comparing thickness variations in two different molds. Figure 4 (bottom) Multi-Vari chart showing that position of loading preforms is important to process. Part C of chart shows improved process.

comes a significant factor in the case of non-rigid bodies, such as the elastomeric materials.

For all of these reasons, the simple PCA must be supplemented with other techniques or supplanted altogether when its limitations cannot be abided.

This article will describe three such methods. They are:

I **The multi-vari chart.** This is a graphical method of picturing and studying the process Spread in a way that permits visual estimation of the degree of contribution of stream-to-stream, time-to-time and within-pieces variabilities to the total Spread.

II **The Span Plan.** This is a systematic scheme for step-by-step dissection of the process Spread into long-term time-to-time, short-term time-to-time, stream-to-stream, within-piece, error of measurement and capability factors.

III **The Analysis of Variance.** This method is the mathematical analysis which forms the underlying principle of I and II above.

In these methods, as will be noted, the concept of capability analysis has been broadened. Whereas, in the simple PCA, all of the causes for disparity between the Spread and the Capability were assumed to be due to instability of the process with **time**, these new methods conceive that other factors may contribute to the Spread. Hence the Spread is thought of as a composite of several "sources of variation" so that it must be "dissected" into its components in order to learn what kind of action will be most successful in improving the uniformity of the process.

DISSECTION BY THE MULTI-VARI CHART

The Multi-Vari chart (See Fig. 2) is a simple graphical chart similar to an X chart of individual measurements (See Dague and Hinchen, Fig. 2), except that it has a "third dimension." In order to show within-piece variability, each piece is measured at two or more positions around its diameter, along its length or across its surface, as the case may be, and these readings are then plotted as a single vertical line on the chart. The line is drawn so as to connect the minimum and maximum values of the positional readings of an individual piece. As in the conventional control chart, a series of successive pieces is usually taken from the process (from each stream, if multi-streams are present) from time to time. Separate charts are usually drawn for different streams, preferably on one sheet of graph paper for easy comparison. Tolerance limits, rather than control limits, are shown on the chart, since it represents individual measurements rather than averages.

Interpretation of the Multi-Vari chart proceeds along these lines:

1 Inspection of the **lengths of the vertical lines** compared with the tolerances indicates the magnitude of within-piece variability. When the average length amounts to one-half of the tolerance or more, it is likely that something needs to be done (assuming the Spread is greater than the specifications) to reduce the within-piece variability. Almost invariably, this points to repair or modification of the tooling or the work-tool alignment. For example, cavity straightness, squareness, taper, and align-

ment are frequent suspects when within-piece variability is too great.

2 Examination of the scatter among successive pieces provides a measure of the Capability of the machine. If desired, this may be expressed quantitatively by the $6\bar{R}/d_2$ formula, in which $\bar{R}$ is the average range of the consecutive maximum (or minimum) readings. When the Capability is inadequate to meet the tolerances, as shown by excessive scatter, then the indicated action is reduction of the consecutive-piece variability by careful examination of the physical factors which enter into the machine cycle. For example, in an injection molding press, these factors affect the **ability of the press to reproduce its cycle** at each closing: steadiness of pressure, steadiness of material feed rate, steadiness of temperature, nozzle cleanliness, tightness of clamping, etc.

3 Examination of the positions of the plotted lines from one sample cluster to another give a measure of the extent of contribution of time-to-time variability to the Spread. To reduce excessive time-to-time variability requires scrutiny of the physical factors which could cause **drifts** or **trends** in the process. In a molding operation, some of these are: barrel-to-barrel differences in molding material, improper feed rate; excessively frequent pressure, temperature, cycle time, or other adjustment by the operator; erratic pump pressure, etc.

Figure 3 depicts the use of a Multi-Vari chart to discover the reason for a large percentage of out-of-tolerance parts on the thickness of an injection-molded razor blade dispenser*. In this case, the chart was made on the basis of samples drawn by the customer, rather than the molder, and thus emphasizes the ability to diagnose the nature of excessive variation even at a distance from the actual operation. To obtain the data, the customer drew a sample of one piece per cavity (20 cavity mold) out of each shipment of about 10,000 pieces. Mold and cavity identification on each piece made it possible to do this. This sampling procedure was repeated for five different shipments, yielding 200 dispensers for measurement and analysis. (There were 5 pieces from each of 20 cavities from each of molds B and C.) Each dispenser was measured for thickness in two positions—at opposite ends of the piece—and the results plotted as shown in Figure 3. The representation of a piece by a dot rather than a line simply means that the two readings were identical on that piece.

Diagnosis from the chart was as follows:

1 The lengths of the vertical lines are small enough so that within-piece variability can be dismissed as a problem.

2 Since time-to-time variability has been included within each cavity cluster by the method of sampling, it is clear that the cavity-to-cavity differences are the major problem—they are large compared with the composite of Capability and time-to-time.

3 In the case of **C Mold**, "surgery" is definitely necessary, by actually opening up the cavity, runners or gate dimensions, particularly on cavities #1, #9 and #17.

4 In the case of **B Mold**, cavity differences, although present, are small enough so that an increase in the thickness of all cavities (as, for example, by increasing molding pressure) may be able to avoid repair of the mold.

At the Northern Industrial Chemical Co. in Boston, Mass., the Multi-Vari Chart has been used to help solve a baffling problem in control of centrality. The piece was a large 2 pound arc quencher housing, molded of phenolic material in a 20" ram compression press. The case is box-shaped, with a molded slot running the length of one of the narrow sides. Then centrality of this slot is an important functional dimension in the end-use, carrying a specification of .031" maximum side-to-side difference from the slot edge to the perpendicular wall. A chart was made by sampling five consecutive cases every hour and plotting the **difference** in reading between the left and right sides of the case adjacent to the slot. (On this chart, "**O**" is at the center of the chart; lines extending upward from "**O**" indicate that the right side is wider; lines extending downward from "**O**" indicate that the left side is wider.)

Figure 4 (a) shows a portion of the initial chart, pointing to minor piece-to-piece and time-to-time variabilities but a major within-piece difference. It was clear that no real improvement could be made in centrality unless this difference could be materially reduced. This conclusion led to a series of experiments on the size of preforms and the exact position of loading them into the mold. Methods **A, B,** and **C** were tried alternately for five consecutive pieces each. Figure 4 (b) is an excerpt from the **Multi-Vari** chart during these trials. It was quite evident that the centrality of the molded piece was highly sensitive to the position of loading of the preforms. Since **Method B** gave the best results, it was adopted as Standard practice and the hourly chart of Figure 4 (c) resulted.

For the reader who wishes a fuller discussion of the Multi-Vari chart, the article "Diagnosis with Diagrams" referred to above is suggested.

DISSECTION BY ANALYSIS OF VARIANCE

A highly effective, statistically reliable method of dissecting the variability of a process is by means of statistical techniques known as the Analysis of Variance. In this method, data are taken from the process in a manner similar to the Multi-Vari chart, or by various other carefully designed procedures so as to permit the effect of the time-to-time, within-piece, stream-to-stream, and other factors to be measured. Then, by prescribed computational procedures, the analysis determines the significance of each of these factors, compared with the consecutive-piece variability. The significance is an exact one and may be expressed in probability terms, or may be expressed in terms of the actual contribution of each of the factors to the total Spread.

Treatment of the computations and interpretations of the Analysis of Variance is beyond the scope of this series of articles. The interested reader is referred to the references for further information.

DISSECTION BY THE SPAN PLAN

The Multi-Vari chart and the Analysis of Variance each have certain advantages and certain limitations in accomplishing the dissection of process variability. In the case of the Multi-Vari chart, the graphical and non-statistical features are distinct advantages for simplicity of presentation to shop people. However, it admittedly leaves something to be desired from the standpoint of precise analysis and interpretation. The Analysis of Variance, on the other hand, gives very precise and quantitative answers, but is utterly unintelligible to most shop people. Many have hoped that a method might be found

*Example taken from "Diagnosis with Diagrams," L. A. Seder, "Industrial Quality Control," January, 1950.

Figure 5. Span Plan analysis of size of an injection molded piece determines variation from lot-to-lot, and within-lot.

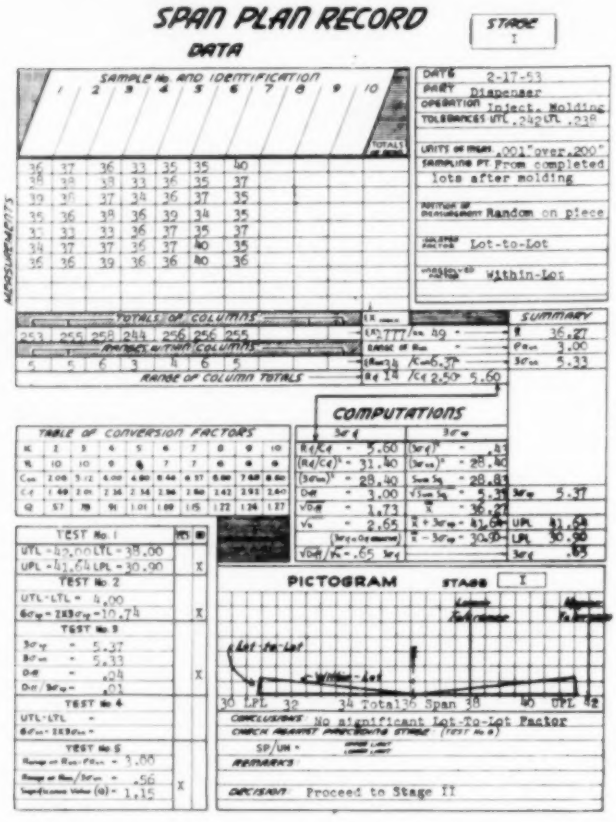
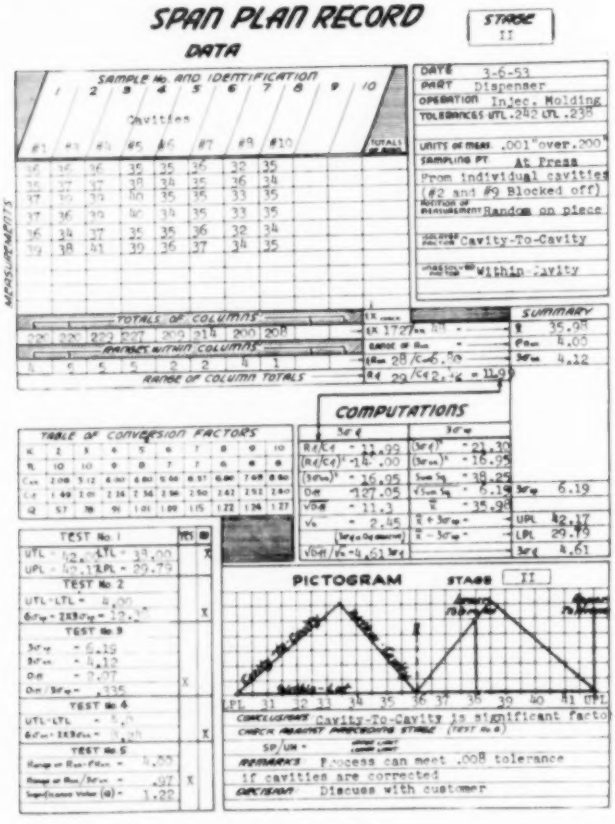


Figure 6. Span Plan analysis shows that cavity-to-cavity differences are responsible for within-lot variability in molded part.



which would have just the right combination of precision and simplicity.

The Span Plan of process capability analysis has recently been developed in an effort to fulfill this need. By employing the Range method of estimating standard deviation, instead of computing the standard deviation directly, the Span Plan has been able to simplify the computations greatly, while still retaining the basic idea and most of the precision of the Analysis of Variance. It also employs a novel graphical method—known as the pictogram—for presenting the results of the analysis in a simple pictorial fashion.

Actually, the Span Plan is more than an analytical technique; it is a completely spelled-out set of instructions for pursuing the dissection of process variability in any process. These instructions include not only details of where to sample the process, how many measurements to make, how to make the measurements, but also how to interpret the results and how to proceed to the next step, depending on these interpretations. It employs five successive "stages" of sampling and analysis to isolate the amount contributed to the Total Spread (or "Span," as it is called in this method) by each of these factors:

1 Long-term time-to-time variability
2 Stream-to-stream variability
3 Short-term time-to-time variability
4 Within-piece variability
5 Error of measurement
6 Capability of the process

One of these is measured at each stage, the sixth one being the residual or "unresolved" variability at the fifth stage. An important practical feature of the plan is that the analysis may be terminated at any stage when a sufficiently large source of variation is discovered to warrant corrective action on the process.

A complete description of the Span Plan cannot be attempted in this article, but one example of its use in connection with an injection molding job will be cited. Although details of the computations and analysis will be omitted for the sake of brevity, the nature of the diagnosis and its significance will be covered.

The part involved in this study was an injection-molded polystyrene dispenser produced in high volume in a 10-cavity mold. Two lugs, symmetrically placed on either side of the piece, are functionally important in the later assembly of the piece with its metal cover. The specified tolerance on lug height of .238"-.242" was not being met and the customer had complained about the wide spread in this dimension. Discussion revealed that oversize lugs were much more serious to the customer than undersize ones and so it was agreed that every effort would be made to stay below the .242" maximum, even though this meant violating the lower limit of .238". However, the molder and the customer immediately reached an impasse on the question of how much tolerance was necessary below the .238" minimum. The molder wanted the lower limit dropped to .230", while the customer insisted on no less than .236".

In order to obtain a factual basis for further discussion, the molder undertook a Span Plan analysis of the operation. The Stage I analysis was done by sampling 7 pieces at random from each of 7 days production, following the Plan's instructions. Only one lug was measured on each piece (the particular one to be measured was randomly selected each time) and the results recorded on the Span Plan Record sheets. (See Figure 5). The purpose of this stage is to determine the Total Span and the relative contributions of lot-to-lot and within-lot

(Please turn to page 36)

Molding Temperature Control with Temperature Indicating Crayons

M. Marsh

Tempil Corp.

132 West 22nd St., New York City

Good results in plastic molding, be it compression, injection, transfer, or extrusion molding, as well as in fabricating operations such as post-forming, impregnating, joining, coating, flame spraying, and the like, depend in large measure on control and maintenance of the prescribed temperatures. Temperature indicating crayons, lacquers and pellets offer a simple, accurate and inexpensive method for determining the recommended temperatures in many of these applications. Some of the typical plastic working processes, and their dependence on temperature, are briefly described.

COMPRESSION MOLDING

By the very nature of the process, compression molding as well as transfer molding is confined almost wholly to the thermosetting resins. These resins harden, or cure, by chemical reaction which is accelerated by heating. Normally, the resins are preheated prior to molding to increase the flow of material and to speed the subsequent cure reaction inside the mold. The amount of preheating is determined by time, temperature, and the energy input due to compression. Excessive preheating may result in pre-curing part of the material, especially if a large preform is involved. Dielectric heating can be used to preheat the phenolics to 275-325°F for 50 to 150 seconds. The requirements vary from job to job.

Phenolics require a mold temperature of about 325°F, the exact temperature depending upon the formulation of the resin, the type of filler used, and the length of cure time. They can be subjected to wider mold temperature variation than the other thermosets. Mold temperatures as high as 450°F have been used in combination with high preheats for short periods and cure cycles of less than 10 seconds. For the melamines and ureas, the mold temperature is kept at about 300°F. Temperature must be closely controlled when molding the ureas, as these materials are especially susceptible to burning. Alkyd molding compounds also require a mold temperature of about 300°F.

Mold temperatures can be monitored with temperature indicating crayons. One simply selects a crayon of the appropriate temperature rating and marks the mold with it before heat is applied. The crayon-like mark made in this fashion will melt as soon as the mold reaches the temperature rating of the crayon used. Alternatively, the mold can be touched or stroked at frequent intervals with the appropriate crayon during the heating process. The crayon will leave a dry mark below its rating and a liquid streak as soon as its specified temperature has been reached.

POSTFORMING

A thermosetting laminate can be successfully formed by "flash" heating to a point just below its blistering temperature. The secret of obtaining good results with this process lies in the use of correctly built forming dies and a carefully controlled heating technique.

Heating is the most important variable in the post-forming process. Because a thermosetting laminate can be successfully post-formed only between relatively close temperature limits, it is necessary to have uniform heating over the entire area to be formed. The operating temperature range is restricted by two factors. First, the material will begin to blister in the neighborhood of 350°F. Second, the material is likely to crack on forming if its temperature drops below 290°-300°F. In view of these limiting conditions, it becomes apparent that uniform heating is indispensable for best results when forming thermosetting laminates.

Temperature-indicating crayons and temperature-indicating liquids for signalling recommended post-forming temperatures have served to take the guesswork out of this critical heating operation. One of two methods is used. For instance, if the plain side of Formica is to be heated, the area involved is determined and marked with a 325°F crayon. This will leave a chalk-like mark which on subsequent heating will melt to a liquid smear as soon as 325°F is reached. If the decorative side of Formica is to be heated, small pieces of Scotch tape are placed at intervals along the area to be heated and indicating lacquer (325°F) is daubed on the tape. The lacquer dries almost instantly to a dull smear which liquefies sharply on subsequent heating as soon as 325°F is reached. It is worth noting that on cooling the melted lacquer will re-solidify with a glossy or vitreous appearance distinctively different from the original mark, and this characteristic makes it possible to interpret the heat distribution in the post-formed zone after the bending or other operation is completed.

Temperature crayons can be used effectively to check uniformity of temperature distribution throughout the tubular Chromalox heater used for bending large sheets of plastic laminates, and for determining the correct heating time required to reach post forming temperatures.

SHELL MOLDING

This relatively new process for making expendable foundry molds uses dry sand and powdered thermosetting phenolic resins which serve to bond the sand to make a serviceable mold. The sand and resin are first mixed mechanically and dumped onto a hot metal pattern, allowed to remain there a few seconds and the excess

dumped off or dropped out. The pattern, surmounted by the shell mold, is then immediately heated in an oven until the resin binder is thoroughly hardened. The shells are then removed from the pattern and are ready for use.

There are three factors which govern the results of shell mold production cycles:

1. Oven temperature
2. Pattern temperature
3. Time in which the resinous binder will cure.

The oven temperature can be thermostatically controlled and therefore maintained constant at the prescribed temperature.

The pattern temperature can vary considerably, depending on the time it remains in and out the oven during cycle. There is also considerable loss of heat in the pattern when the cold sand-resin mix is dumped on its surface. The recommended temperature of the pattern should not be less than 350°F and should average 500°F (plus or minus 30°). Pattern temperatures that are too low will cause the shells to be too thin and weak, and may be responsible for drop-off (portions of the shell falling into dump box). Pattern temperatures that are too high will result in shells that are too thick, and may cause warping and splitting.

Curing of a shell mold is primarily a function of time and temperature. The higher the temperature, the shorter the curing time. One supplier of mold resins suggests curing in an oven temperature range of 600° to 700°F, to attain a pattern temperature of 350° to 500°F, depending on the thickness of the shell. At a pattern temperature of 375°, a shell mold having a thickness of approximately 3/16" will be cured in a dwell time of approximately 15 seconds. Overcuring (pattern and oven temperatures too high, time of cure too long) or undercuring will produce weak shells.

A satisfactory control of pattern temperatures is obtained by using temperature crayons. Spot checking the pattern surface at suitable intervals with one or more crayons of the appropriate temperature rating will usually suffice. The crayon will leave a dry, chalk-like mark below its temperature rating, and a liquid mark when the pattern reaches the temperature rating of the crayon used.

The usefulness of temperature indicating products is not limited to molding operations Crayons, lacquers and pellets have found many other important applications in the plastic industry, such as the following examples.

POLYETHYLENE COATING

Polyethylene coating—as a corrosion preventative—can be applied to metal surfacees with a flame spraying gun. The process is simple. The part is cleaned to remove all dirt and grease and sand blasted if possible. (The sand blasted surface provides a good mechanical bond between the coating and the base metal). Preheating is the next step, since a surface temperature of 425°F is needed in order to produce good adhesion of the polyethylene coating. Crayon 425°F is recommended for determining the prescribed preheat temperature. The working area is simply marked with a 425°F crayon before preheat is applied. As soon as the mark melts on subsequent heating, it is an indication that 425°F has been reached. The polyethylene is then applied by means of a flame spraying nozzle. In this device the polyethylene powder is blown by means of compressed air through the flame cone of an oxy-acetylene or oxy-gas burner, the velocity of the powder stream being adjusted so that the polyethylene emerges as molten droplets and these coalesce to coat the work surface. The coating solidifies firmly bonded to the surface.

DACRON, NYLON, AND RAYON PRESSING

While Dacron, Nylon, and Rayon are not plastic materials in the colloquially accepted sense of the word, they should properly be classified as such. These fabrics present many new problems during and subsequent to their manufacture. For instance, excessive temperatures ruin them and ironing at correct temperature is therefore more critical than with natural fibres. It is important that the temperature of irons—whether they are steam, electric, or gas—be closely controlled. Crayons provide a simple and accurate means of determining the temperature of irons. It is sufficient to make a mark on the iron with the proper crayon before heating begins. The crayon mark will liquefy as soon as the iron reaches the specified temperature.

OTHER APPLICATIONS

The use of temperature indicating products in connection with the several processes described in preceding paragraphs by no means exhaust their possible applications in the plastic field. For instance, to name only a few others:

A. Welding of polyethylene.

B. Vacuum forming of large plastic parts.

C. Extrusion of thermoplastics.

D. Rubber curing and the related tire retreading and rubber V-belt splicing.

E. The entire range of synthetic resin paints as well as their use as baked-on finishes.

All the mentioned applications merely serve to illustrate the versatility of these products as a simple and accurate means of identifying critical or significant temperatures. Undoubtedly the examples cited will suggest other instances where effective use can be made of these temperature indicating materials, not only in the manufacture and subsequent fabrication of plastics, but in related processes ranging from maintenance and repair welding to hardening and tempering of steel tools, dies, molds, and the like. In short, it seems safe to say that in almost any process where temperature is an important factor effective use can be made of these modern aids to industry.

Book Reviews . . .

(continued from page 4)

fillers for resins. There is limited treatment or absence of reference to certain phases and problems as reflected by current U.S. practice. Representative are: resin fibre bond, fibre surfacing, surface preparation and treatment for finished molding coatings, pre-saturated mat, machining techniques (and problems), glass and fabric (natural and synthetic fibres) laminate combinations, joining and integral use of metal or other fittings and reinforcements.

However, for an industry which formulates and compounds prior to forming-fabricating, this is an excellent reference text. The concise and complete treatment of resins and glass forms will well serve those who are to the fore in developing new applications, the tooling and fabricating technicians and engineers.

Future texts of this type should be enlarged in scope to include other reinforcing materials and a comprehensive study of non-mineral fillers. The former to better represent the industry as it is, "Reinforced Plastics." The latter because of the requirement of lower cost (per cubic inch) if reinforced products are to achieve mass markets.

R. R. Meyer

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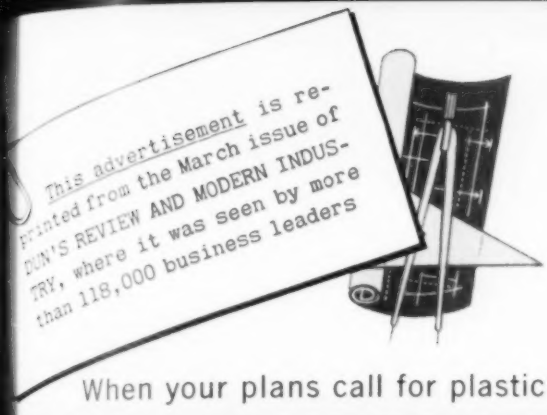

This advertisement is reprinted from the March issue of DUN'S REVIEW AND MODERN INDUSTRY, where it was seen by more than 118,000 business leaders

Every age has fathered its artisans. In the past, wood carvers, silversmiths, steel forgers all fashioned useful and beautiful products from the materials at hand.

Today, new kinds of materials have been created. And a new group of craftsmen—the molders of plastics—has emerged to blend timeless skills into modern techniques of mass production. Pictured here are two of the many specialists who are now molding plastic materials into products that are serving every industry, every home. Monsanto, a major producer of high-quality plastic materials, salutes these craftsmen who are helping to mold America's tomorrow.

When your plans call for plastic parts or products, consult an expert custom molder

Oscar Niemi, Supt. Injection Molding, Santay Corp., Chicago

Over the last 15 years Mr. Niemi has turned out plastic products on all types of equipment, ranging in size from 2-oz. to 60-oz. machines. Perhaps the most outstanding job under his guidance has been an electronic part, a coil form with 4-wire inserts molded in. The coil form has been running over 5 years, 85 shots per hour in a 12-cavity mold. He has also run a 21-in. television "lens" in a single cavity mold (using 8 different molds) for over a year and a half, each molding optically perfect.

Cornelius DeBlock, Mack Molding Co., Arlington, Vermont

More than 26 years ago "Casey" DeBlock began learning mold design and plastics technology in the machine shop of Mack Molding. Today, as pulse-taker of Mack's production line, he supervises the operation of injection molding presses which vary in capacities from a few ounces to 15 pounds per "shot". Casey was one of the first to recognize the need for "lubricant" in injection molding compounds. His suggestions helped chemists improve the performance of plastic materials for broader use.

MONSANTO CHEMICAL COMPANY,
PLASTICS DIVISION, SPRINGFIELD 2, MASS.

MONSANTO

LUSTREX
Styrene Plastic

runnerless MOLDING

Ernest P. Moslo

Moslo Machinery Co.
Cleveland, Ohio

The art of injection molding without runners is not entirely new to the plastics industry. However, it is a subject that is not well known to many molders and can stand a lot of exploratory work.

Runnerless molding can mean additional profits or the difference between profit and loss on many jobs, particularly on very high production items. In many cases, mold construction is considerably more costly than a conventional runner or a tunnel-gated mold. The increased production and the saving of runner scrap, in most cases, more than offsets this additional cost, meaning the differences between profit and loss on a job. After all, scrap sprues and runners are sold at a fraction of the cost of finished parts.

The description of a number of the following hot nozzle molds are illustrated as a hypothetical container mold. We have not attempted to draw or illustrate practical mold design. Many of these experiments were tried on molds producing parts of a different nature.

Illustrations are not exactly to scale, in many cases. They are suggestive and, in all cases, they have been thoroughly tried. Many of the ideas are used in actual highspeed automatic production today.

Runnerless molding covers quite a few tried and proven methods.

- **No. 1. Direct injection from a nozzle into a single-cavity mold.**
- **No. 2. Direct injection from multiple nozzles into two or more cavities.**
- **No. 3. Hot or confined runners to multiple cavities.**
- **No. 4. Production of phonograph records with a runnerless method.**

Direct Injection from a Nozzle into a Single-Cavity Mold.

On one of the first trials we used an extension nozzle as shown in Drawing No. 1. This nozzle was one inch in diameter, and the end of the nozzle formed the bottom of the cavity. This was fairly successful. However, due to the fact that the hot nozzle was in contact with a large area of the molded part, a nozzle impression was left on the molded piece and the speed of production was limited. The internal construction of this nozzle was good and very little freezing of the nozzle itself was experienced in production. It was, however, rather important to keep the contact area of the outside diameter of the nozzle, with the mold, at a minimum. It was also necessary to heat this nozzle extension to keep it in operation. It was very important to keep accurate temperature control on the nozzle at all times for completely satisfactory results.

Should the nozzle freeze for some reason or other while the machine is down, there are two methods of getting it back into operation. The first is to elevate the temperature of the nozzle 20° to 30°. The second is to back the nozzle out of the mold opening completely and let it heat for 30 to 60 seconds. It is then ready to go back into production.

In our developments, we continued to try smaller and smaller diameter nozzles of this same general construction. Finally, we used a nozzle with ¼" outside diameter, as shown in Drawing No. 2. In reducing this diameter to this size, the danger of freezing the nozzle increased. Under the circumstances, it was very important to keep the amount of metal-to-metal contact between the mold and the nozzle at its very minimum. This nozzle worked very well. Production increased over that obtained when using the nozzle shown in Drawing No. 1, due to the small-

or contact area of the nozzle itself with the bottom of the molded part. The impression left by the end of the nozzle was not as unsightly as in the case of the 1" diameter. On the bottom of a part such as a container, a compact, a box, or a part that is used in assembly where the mark is covered, this type of construction is very good. This is definitely an excellent approach to automatic runnerless molding with a nozzle in direct contact with one or more parts.

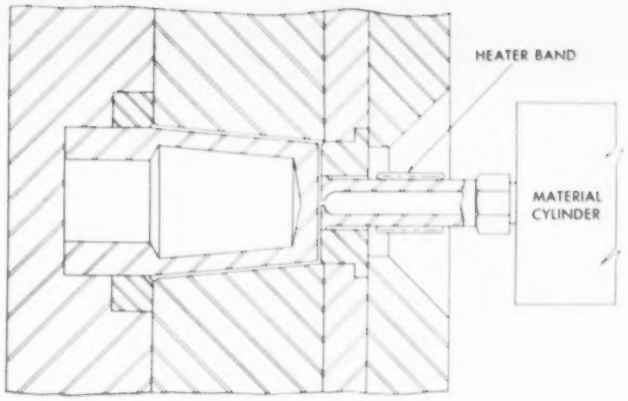
Drawing No. 3 shows a continued development. This nozzle has a 90° taper on its outside diameter. The nozzle tapers to a 3/32" diameter, and this diameter protrudes into the bottom of the mold cavity. Actually, this has been the best construction so far. The internal construction of this nozzle is very important. We used a ½" diameter straight bore, reducing this diameter on a 60° included angle to an opening of .030" to .040" in diameter. This was the gate into the cavity. The size of the opening depended entirely on the part that was being produced. This nozzle left a very minimum of surface mar on the finished part. Should land be left on the opening end of this nozzle, rather than bringing the 60° taper completely to the gate or opening, freezing will occur. Another problem with this type of construction is that the surface contact area between the nozzle itself and the mold must be kept to a minimum. It is practical to relieve part of the surface contact area. A beryllium copper nozzle tip will work much better, in many cases, than tool steel. Temperature control is of utmost importance for continued, satisfactory operation.

Illustrated in Drawing No. 4, is a disc that is .023" in thickness and 4" in diameter. We were approached by a customer asking us if it were possible to mold this disc in one of our machines. He advised that his company had a mold that had been in existence for about 3½ years, but that it had been impossible to mold this part in production. Attempts had been made to run this mold in machines as large as 8-ounce capacity. We informed the customer that we could mold this part, having in mind that we would put it on a special machine on which we were able to mold at an injection pressure between 25,000 and 35,000 PSI.

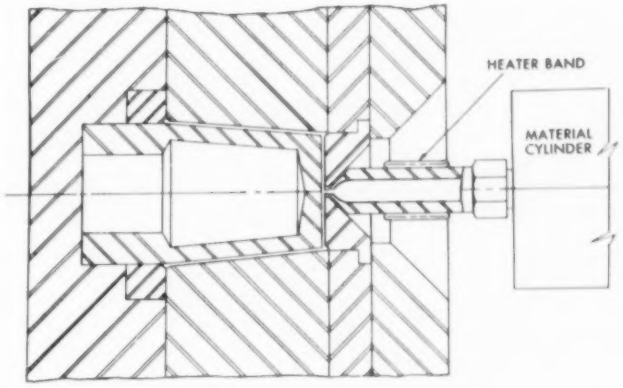
When we received the mold, we found that it was much too large to be installed in our small machine. We rebuilt the mold into a standard 8"x9" mold base and installed it in a standard MOSLO Model 73 2 ounce high-speed fully automatic machine having a maximum injection pressure of 16,000 PSI. We were able to mold this part on this standard machine and turn out satisfactory finished parts at a production rate of 720 pieces per hour, with this single-cavity mold. We molded this part in both hi-impact styrene and in a free flow styrene. The nozzle construction was the same as that shown in our Drawing No. 3.

Illustrated on Drawing No. 4, is another disc that was run with the same type of nozzle. This disc is .032" in thickness and 5" in diameter, and slightly curved. The material used is a special high-heat co-polymer of styrene that is much more difficult to mold than ordinary styrene, but, even with this tough material, we were able to mold over 600 of these discs per hour, fully automatically, in the same machine. So, it is my belief that nozzle construction is of utmost importance. Originally, the above part was molded with an edge gate. More strains were apparent in the part as the result of edge gating from a runner. Center gating from a hot nozzle is a very definite advantage.

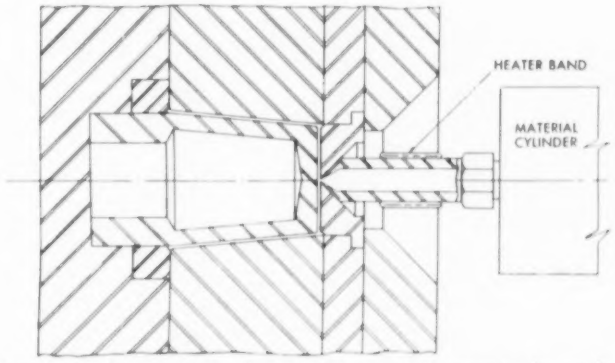
On this particular material, we found that we had better operation by installing a beryllium copper nozzle tip.



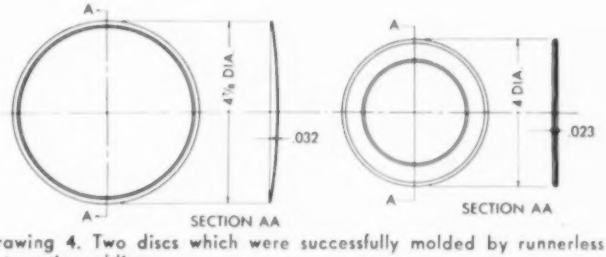
Drawing 1. A first approach to runnerless molding was made with this extension nozzle.



Drawing 2. Extension nozzle of reduced (¼") diameter. Smaller nozzle contact area increased production.



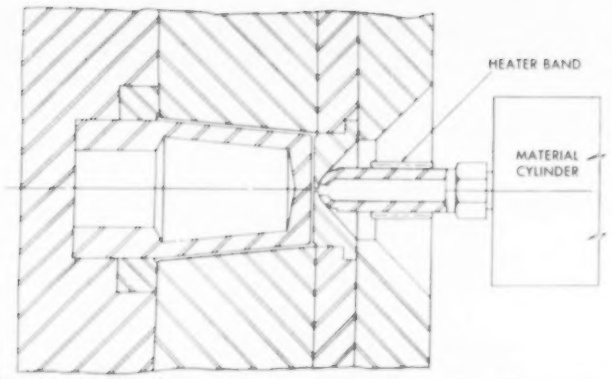
Drawing 3. Continued development brings a 90° taper to the nozzle, and nozzle actually protrudes into mold cavity.



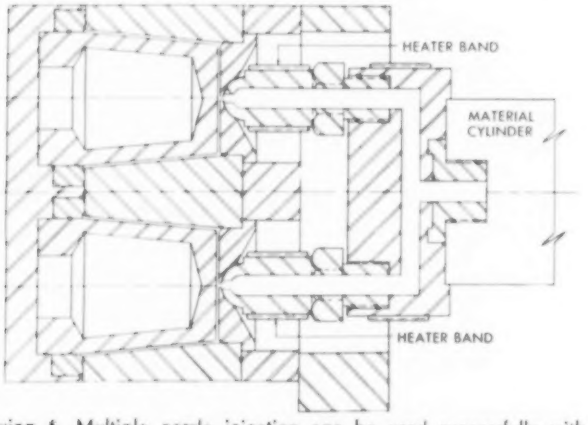
Drawing 4. Two discs which were successfully molded by runnerless automatic molding.

Heat transfer to the material was much better, and freezing at the nozzle was eliminated.

To eliminate the nozzle mark on a molded part, we constructed the bottom of our mold as shown in Drawing



Drawing 5 . This shows an ordinary ball-point nozzle, with a reverse taper. Water cooling of the mold near the nozzle is very important.



Drawing 6. Multiple nozzle injection can be used successfully with any of the previously described type nozzles. Construction shown gives a very rigid assembly.

No. 5. In this case, an ordinary ball-point nozzle was used with a reverse taper extending a short distance back into a larger mass of hot plastic. As in all other cases, the nozzle itself was heated. Actually, we have exaggerated the distance from the end of the nozzle to the bottom of the molded part, as well as the gate diameter. This distance from the end of the nozzle to the bottom of the cavity must be kept as short as possible. A reverse taper should extend from the nozzle into the cavity. Again, a beryllium copper nozzle or a nozzle with a beryllium copper tip will work to a better advantage than a steel nozzle.

The water cooling of the mold near the nozzle is of utmost importance, in order to keep production at its highest peak and to produce a good finished part at the gate. The temperature of the mold core and cavity must be controlled very carefully as well as the temperature of the nozzle. If all the elements are controlled, a very smooth gate break-off can be maintained and can be blended into the design of the finished molded part. It is impossible to tell exactly what this control must be, as is would be entirely different for each type of mold and for each type of material molded.

A problem that has presented itself innumerable times in the plastics industry, and is evident in some runnerless molding, but is very controversial, should be discussed. This problem is a very small diameter stringer that pulls away from either a single nozzle or multiple nozzles, as the part leaves the mold. The part is retarded in its fall, due to these stringers. The clamp will close on the part and the machine will miss a cycle. Several machinery manufacturers have supplied methods of removing these stringers or of cutting them off at the nozzle. This requires slow, cumbersome moving parts that slow down cycles considerably.

We have found that stringers only occur if temperature controls are not proper, and where excessive heat is applied to the material in the plasticizing chamber. It is my thought that, with adequate plasticizing capacity in the heating cylinder of an injection molding machine, with good nozzle design, and with good temperature control on the plasticizing chamber and the nozzle itself, stringers are entirely unnecessary.

Our conclusion is that these stringers can be eliminated completely with good design and good control.

Direct Injection from Multiple Nozzles into Two or More Cavities

There are definite advantages as well as disadvantages to this type of molding.

There are quite a few methods of multiple nozzle injection that have been tried successfully. Drawing No. 6 shows a manifold directly attached to the heating cylinder of a molding machine. Nozzle design can be any of the previously described nozzles. One of the advantages of this type of construction is a very rigid assembly. Excellent heating to the manifold and to individual nozzles can be provided. Passages of plastic from the heating cylinder to the cavities are short. Temperature control is very accurate. Heat transfer from the manifold to the mold is very slight. One of the main disadvantages of this type of construction is the fact that it is necessary to provide a special platen for this type of installation. These platens can be furnished with a pre-determined number of openings for nozzles on a given pattern. However, the machine then becomes limited to this pattern for mold design.

In Drawing 7, is shown an actual layout of a manifold furnished a customer with a Moslo Model 75 machine. As you will note, the heating cylinder and nozzle arrangement are standard. The manifold is a floating member. The only contact that it makes with the mold is through the tips of the multiple nozzles. This particular mold was for the production of polyethylene vials that are not shown completely in this drawing. The manifold was loosely held against the mold by three socket head screws, while the mold was installed in the injection machine, centering of the manifold and the mold was directly on the nozzle of the machine. After installation, pressure on the stripper bolts can be released and the entire unit is a floating member. This we believe to be excellent construction for multiple nozzle molding. The illustration shows a 4-nozzle arrangement. This can be any number of nozzles. The manifold need not be round, it can be rectangular, square, or any shape. The most important factors are adequate heat and temperature control.

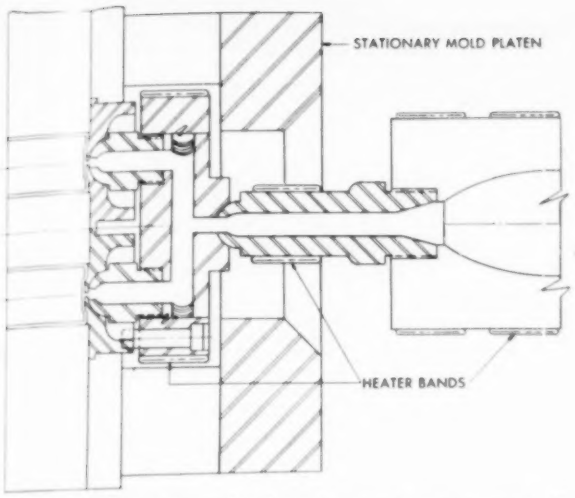
Hot or Confined Runners to Multiple Cavities

The process of using hot or confined runners to multiple cavities is an old art. However, it has had and can still stand additional improvement. We know of many hot runner molds in existence that are giving the molder excellent production and also creating some problems.

Illustrated in Drawing 8 is a combination of two styles of hot runner molds. The method we will discuss first, is shown on the right-hand side of the cross-section.

Illustrating one method of building a hot runner mold, I quote from an article: (Reference 1)

> "In a hot runner mold, the gate half of the mold is composed of two separate plates known as the heater plate and the runner plate. These



Drawing 7. Excellent construction for a four-nozzle arrangement. The manifold can be of any shape.

two components are bolted together. The heater plate is equipped with electrical heating elements located in such a manner that the over-all temperature of the plates is as uniform as possible. Thermostatic control maintains both the runner plate and the heater plate at a temperature which is sufficient to keep the thermoplastic material in the runners in as plastic a state as it is when it leaves the injection nozzle."

---and---

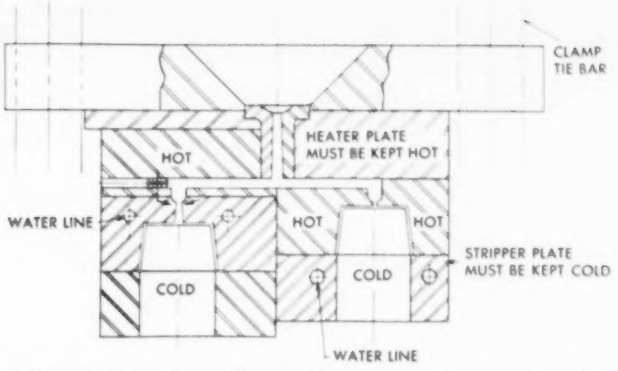
"One of the first problems that had to be overcome had to do with strengthening the assembly of the heater plate and the runner plate. Four bolts were used for this purpose in the first mold. When the first shot was taken, these four bolts snapped, and the hot plate and runner plate fell apart. This indicated the terrific pressure which was exerted because of the projected area of the runner."

---and---

"Because of the high rate of heat transfer between the hot cavity side of the mold and the cold force plug side of the mold, it was found that a circulating medium colder than tap water was required on the force plug side in order to cool the polyethylene quickly enough to obtain a fast molding cycle. Eventually a complete refrigeration and circulating system was built, in which an ethylene-glycol solution is maintained below 32°F. With this low-temperature cooling medium on the force plug side of the mold, cycles better than four shots per min. are maintained."

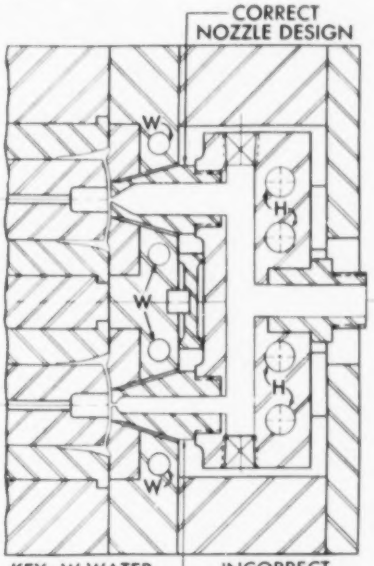
In the left hand section of Drawing No. 8, is shown a type of hot runner mold in common use in the industry. Both of these designs have their limits. It is very difficult to keep the hot side of the mold hot enough and the cold side of the mold cool enough for rapid molding cycles. A lot of heat is wasted by excessive cooling on one side of the mold and excessive heating on the other. Heat transfer to the machine platen itself is also a problem.

The hot nozzle arrangements for a single cavity, as well as for multiple cavities that have been described, I believe, are of advanced design and are more economical to operate, from a heat input standpoint as well as from an increased production standpoint, than the molds illustrated in Drawing 8. Isolation of heat from the mold and from the machine, is simplified. Temperature controls can

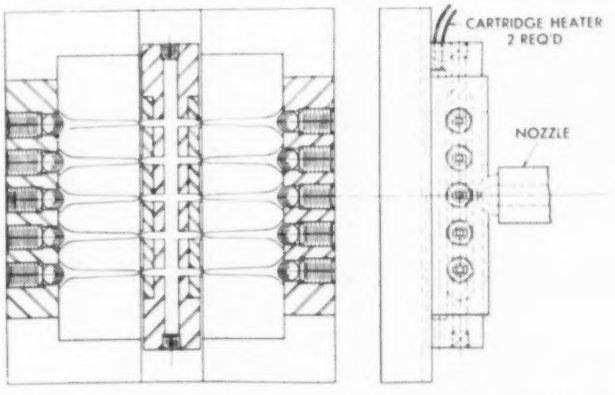


Drawing 8. Two styles of hot runner molds in common use. Heat control is different with these.

Drawing 9. Cross-section of a six-cavity mold, showing correct and incorrect design.



Drawing 10 (below) Ten cavity hot-runner mold for golf tees.



be very accurate. There is no bucking of heating and cooling in the same mold.

In Drawing 9, is shown an exact cross-section taken from a customer's mold that shows advanced design of a hot runner setup. This is a 6-cavity mold producing caps for an aerosol can. The cross-section is full size. Illustrated is an incorrect and a correct nozzle design. The incorrect nozzle design had too small a diameter hole and too much land in the gate. The nozzles froze constantly. We recommended that the diameter of the hole through the nozzle be increased from ¼" to ½" and a 60° included angle be machined directly through the end of the nozzle to an orifice approximately .040" in diameter. With this type of

(please turn to page 36)

AROUND THE WORLD

GERMANY

KUNSTSTOFFE

Vol. 45, No. 1, January, 1955

Abstracter: Anne Schwend

EFFECTS OF PLASTICIZERS—by Ernst Jenckel

A report on the investigation and determination of the second order transition point, particularly in polystyrene, esters of polymethacrylates and naphthylsalicylic acids either by deducing it from the volume or by means of an Abbe refractometer with a temperature range of -150 to +392° F. There is only a limited number of plasticizers which may be transferred into a glasslike status. Hence, there is equally only a limited number of plastic-plasticizer solutions the second order transition point of which may be determined at all ratios of mixture. The curves obtained by measuring the refractive indices in dependence from the composition at constant temperatures of the molten mixture reveal that the refractive index of the melts takes on an additive attitude. On the other hand, a diagram of the change of the refractive index of the compounds in glasslike status yields convex curves from which results that the refractive indices of such compounds are greater than could additively be deduced from the components in glasslike status. The corresponding volumetric curves are concave which signifies that the volume in glass status is smaller than would result from additivity.

The lowering of the second order transition point in plasticized polymerizers depends in the first instance on the second order transition point of the pure plasticizer, as is explained. The characteristic volumetric contraction of glassy solutions is directly proportional to the difference in second order transition points of both plasticizer and plastics and disappears in case both components freeze at the same temperature. If both components consist of rod-shaped molecules of equal length in glassy status, no volumetric contraction will be caused upon mixture, while contraction will be effected in case the length of one type of molecules is shorter than the other since the shorter ones will fill out the holes between the larger molecules, a characteristical feature of glasy structures. It is concluded that materials having molecules of equal length do have the same second order transition points.

PLASTICIZER MIGRATION—by K. Zoehrer and A. Merz

This article reports about methods used by the plasticizer laboratory of the Oel-und Chemie-Werk AG at Hausen/Switzerland at the time of laying down the notes therefor, i.e. October 1953. It was stated during the tests that loss and absorption of plasticizer in contacting materials often differed very much from which it is concluded that the migration of plasticizer may be clearly influenced by the contacting medium. Also, the activity of the films themselves, moist surfaces on films or porosity, etc. may highly influence the result. It is interesting to note prior to absorbing plasticizer a rigid PVC film will first have to be cleared from the slight film of moisture on the surfaces and will lose in weight. Only through higher temperature and longer exposure to the plasticizer of another contacting film will the structure be so loosened that absorption will take place. Tests extended to the Brabender and active coal methods, to the investigation of the interconnection between plasticizer content and migration or volatility respectively and the oil solubility, to fixing the limits of plasticizer extraction by migration into nitrocellulose as well as the influence of rolling time, temperature and thickness of films. The subject of high polymer plasticizers as used in the United States is touched briefly.

PLASTICS IN LIGHTING TECHNIQUE—by W. Sinn

A brief survey on the development of modern plastic light fittings and demands existing as to unbreakability, weight, corrosion and weather resistance and mechanical strength against static loads.

MEASURING THE HEAT-SEALABILITY OF COATED CELLULOSE FILMS—by K. S. Kunze

The testing methods of the laboratories of Wolff & Co. at Walsrode are published in order to help find a method for the heat-sealing and testing of cellulose films for the packaging industry suitable for standardization. A split-follower apparatus, heated electrically and controlled by thermostat, is described and the context between sealing temperature, sealing power and sealing time investigated. Values obtained at a sealing time of 1 second, a pressure between 28 and 71 psi and a temperature of appr. 230° F. give good results when checked as to tear strength and are well reproducible within limits of 5% for the same film material.

GERMAN STANDARDS

Draft for DIN 53489 for the testing of hard paper and laminated fabries and description of testing methods for the determination of corrosive influences on copper or copper alloys for electric insulators.

INJECTION MOLDING OF POLYAMIDES—by Fritz Schaupp

The special properties of polyamides in comparison with those of polystyrene, such as higher melting point, narrow melting zone, low viscosity, absorption of moisture and its influence on processing and dimensional stability as well as the relatively high shrinkage are discussed to encourage molders of polystyrene and cellulose acetate to go into the molding of polyamides which offer many advantages and new business prospects for them. The design of a special nozzle for polyamide molding is described in detail.

GLASS FIBRE REINFORCED POLYESTER MOLDING COMPOUNDS—by L. Bajko

The properties of "Keripol," a new polyester product by Internationale Galalith-Gesellschaft AG at Hamburg-Harburg, which is reinforced with glass fibres of 10 u in dia. and 0.8 to 1.2 in. in length and was only recently introduced on the German market in readily catalyzed form for storing at least five months at room temperature, are discussed. This compound which may be molded in customary compression or transfer tools, preferably flash overflow molds, shows

(Please turn to page 37)

SECTION NEWS

Edited by

Stanley Bindman

Jamison Plastic Corp.
1255 Newbridge Road
North Bellmore, L. I., N. Y.

New York

Injection Machine Standards and Thermocouple Location Are Topics

A. M. Merrill

The New York Section held its regular monthly dinner meeting on February 16th at the Gotham Hotel with president G. Palmer Humphrey, R. C. Molding, Inc., presiding. Approximately 84 members and guests were in attendance to hear A. R. Morse, president of Injection Molders Supply Co., discuss "Thermocouple Location in the Injection Molding Machine Heating Cylinder," and David J. Sloane, vice-president of Lester-Phoenix, Inc., speak on "Specifications and Standards on Injection Molding Machines." Both speakers illustrated their talks with film slides.

Mr. Morse's discussion basically involved the problems of molding the new improved compounds on what might be termed obsolete equipment. Molders have found that the evolution of high quality compounds has narrowed the gap between proper molding temperatures and decomposition temperatures of the materials used. The answer, implied by Mr. Morse, seems to lie in increased instrumentation as applied to the heating cylinders. Special emphasis on having heaters adapted to individual injection molding machines, according to Mr. Morse, would provide uniform and completely controlled heating to further reduce the dangers of decomposition.

Mr. Sloane spoke on the advantages and difficulties of achieving standards pertaining to injection machines. Plasticizing capacities and clamping pressure standards were just two of the more important matters aired. Mr. Sloane expressed the hope that interchangeable mold clamps that will fit any comparable injection machine will be a reality within the near future.

With the completion of Mr. Sloane's talk, questions were received from the general membership.

Because of the subjects involved, committee reports in the business session preceding the talks were held to a minimum. Arthur S. Jacobs, Augusta Plastics, Inc., briefly outlined the chapter's intensified membership drive. Also announced were the Section's new monthly newsletter, and the imminent formation of a vacuum forming group.

A door prize donated by Monsanto Chemical Co. was won by Mr. Jacobs.

The following 45 new members have been added to the New York Section during the past month: Raymond W. Angelo, chemist, Arma Corp.; Peter Brogi, owner, Colonial Tool & Die Co.; Kendal A. Briggs, vice-president-production, Catalin Corp. of America; Dino Chaparas, supervisor of pipe extrusion, Waljohn Plastics, Inc.; John Daidone, secretary, Starloid Plastic Corp.; Michael James DeLuca, Jr., genl. mgr., LaBarb, Inc.; Herbert Emanuel Engemeyer, sales rep., H. Muehlstein & Co.; George Fishman, secretary-treasurer, Keel Mfg. Corp.; Benjamin Kinberg, plant mgr., Emenee Industries, Inc.; J. Kenneth Lund, consultant, H. G. Jacobs Co.; William Leidel, Jr., owner, Fred Wacker Co.; Murray Marlowe, president, Claremont Pigment Dispersion Corp.; Robert James Mills, tool engineer, Grumman Aircraft Corp.; T. Frank Newsham, foreman of Fiber Glass Dept., Grumman Aircraft Corp.; Stanley S. Kadin, project engineer, Celanese Corp. of America; Dale Lloyd Orloff, expediter, Plastic Ware, Inc.; George N. Olson, eastern dist. sales manager, Spencer Chemical Co.; Ronald Michael Pastore, production mgr., Axiom Machine & Tool Co.; C. Stephen Schwendler, supervisor of plastic dept., National Casket Co.; Henry Sax, Dept. head, Stafford Mfg. Co.; Arthur H. Zevin, ass't to vice-pres., Ideal Plastics Corp.; William B. Atchison, Jr., process engineer, Grumman Aircraft Engineering Corp.; John Alico, assoc. editor, "Product Engineering"; Jack Blitz, sales engr., Plastic Molding Powders, Inc.; Peter B. Black, special sales rep., Radio Recepter Co., Inc.; Allan Jeffry Breslau, group leader in tech. service dept., Thiokol Chemical Corp.; William G. Bacon, Jr., vice-pres., E. W. Twitchell, Inc.; James J. Clemens, sales service, Sandee Mfg. Co.; Dr. John E. Campbell, chemist, Behr-Manning Corp.; John B. Campbell, assoc. editor, "Materials and Methods"; Emil Davidson, partner, Davidson Associates; Irving J. Gleich, plant supt. and treas., Block Doll Corp.; Milton S. Hoffman, president, Block Doll Corp.; Joseph B. Loesing, Jr., eastern regional mgr., The Richardson Co.; Maurice F. McGrath, Jr., market research, J. M. Huber Corp.; Thomas P. Murphy, technical rep., Spencer Chemical Co.; Wallace B. MacKenzie, chief chemist, Phelps Dodge Copper Products Co.; Salvatore C. Nilo, chief of Materials & Miniaturization Eng. Sec., Rome Air Development Center, USAF.; Clifford E. Otto, N. Y. dist. sales mgr., Manco Products, Inc.; Norman L. Perry, tech. sales service rep., Argus Chemical Corp.; Harry A. Russell, tech. director, Pantasote Co.; Robert T. Strandwitz, sales rep., U. S. Gasket Co.; Walter Jacob Tanner, tech rep., Witco Chemical Co.; William S. Thornhill, vice-pres., U. S. Polymeric Chems. Inc.; and Howard L. Toft, president, American Printed Circuits Co.

Pittsburgh

New Officers Are Chosen for 1955

President, Mr. William F. Seiler, 1125 St. Martin Street, Pittsburgh 3, Pa.; Vice President, Mr. Erwin A. Rodgers, Stylett Plastics Inc., 148 South 25th Street, Pittsburgh 3, Pa.; Secretary, Mr. Charles Shanta, Shanta Development Co., 319 Bell Avenue, McKees Rocks, Pa.; Treasurer, Mr. J. Q. McClure, Westinghouse Electric Corp., Casting Pilot Mfg.—K-90, East Pittsburgh, Pa.; National Director, Mr. Joseph Schmitt, Koppers Company Inc., Chemical Division, Koppers Building, Pittsburgh 19, Pa. (re-elected).

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Chicago Officials

Rear Row Left to Right: G. C. Heldrich (Director) Continental Can Co., Chicago; M. A. Self, President, Bee Chemical Co., Chicago (Alternate National Director); R. K. Gossett, President, Gossett-Hill Co., Chicago (President); K. A. Rouzer, Plant Manager, GATX, East Chicago, Indiana (Secretary-Treasurer); and Russ Hanna, Hercules Powder Co., Chicago (Director).
Front Row Left to Right: John T. Bent, Eastman Chemical Products Co., Chicago (National Director); Ray Daniels, Amos Molded products Co., Chicago (Director); Lee Hunter, Koppers Company, Chicago (Director); and Earl Wilson, Prefex Plastics, Inc., Chicago (Director).
Absent: Franklin L. Fine, Rohm and Haas Co., Chicago (Vice-President); E. E. Eckenbeck, Jr., Midwest Plastics Products, Chicago (Director).

Chicago

Automation Can Raise Quality Level

R. K. Gossett

On February 16th, more than 100 members of the Chicago Section attended a dinner meeting held at the headquarters of the Western Society of Engineers, Chicago.

Mr. Clifford E. Evanson, Partner, T.A.B. Engineers, Inc., Chicago, addressed the group on a most interesting and timely subject: "Cutting Costs with Automation." Mr. Evanson, a graduate of Illinois Institute of Technology and a registered professional engineer, has been engaged since 1947 in working, through his firm, with automation and its related problems. He stressed that automation can and will have to be used in the future in the plastics industry, even though production may involve making several parts over a short period of time in the same press or extruder. Mr. Evanson listed several case problems in which production rates have been increased many-fold, quality levels raised, labor forces upgraded in degrees of job difficulty, and a company's competitive position in its industry materially improved through partial or complete automation. One of Mr. Evanson's most interesting statements was to the effect that he knows of no case where the adoption of automation has resulted in a decrease in the labor force in the factory involved. In some cases, automation has resulted in a doubling of the number of plant workers, through lower costs and increased product demand.

Mr. Evanson also showed and commented on the Ford Motor Company film "Technology for Tomorrow." This film demonstrates the degree of automation at the Ford Motor Company foundry and engine plants in Cleveland, Ohio.

R. K. Gossett, 1955 President, Chicago Chapter, presented, on behalf of the section, a handsome plastic gavel to M. A. Self, 1954 President, with a vote of thanks for his outstanding work for the Section during the past four years."

Golden Gate

Mold Fabrication Methods Depend On Object Shape

R. G. Newhall

At the January meeting of the Golden Gate Section, SPE, W. B. Layton (Dumont Corporation), Theodore Malianni (S. F. Plastics Company) and Robert Wnukowski (Aero Tool and Die Company) were installed as Directors to replace the out-going members of the Board — Richard Weber, Leonard Faber and Lloyd Griffith. The Board of Directors for 1955 consists of the three newly elected members and the following six Directors whose terms of office have not yet expired: John L. Morrill, Joseph Smith, John Robb, John B. Moore, James Smith and Peter Turkovich. This new Board elected as their officers for the coming year: President, Jack Morrill; Vice President, Ted Malianni; Secretary, Jack Moore; Treasurer, Bill Layton. The outgoing President, Richard Weber, will be the National Director.

The speaker of the evening was Leonard Faber of Precision Manufacturing Company, who reviewed recent developments in the plastics industry, with particular emphasis on techniques of mold fabrication. Mr. Faber remarked that a major objective of the mold designers and fabricators is to decrease cost while increasing quality. There are five commonly used methods of making dies for compression or injection molding:

(1) **Hobbing** is probably the best known and most widely used procedure. In this technique a hardened steel hob, identical in shape and size to the desired plastic piece, is forced into a soft carbon steel matrix under high pressure. The cavity thus formed is then hardened for use.

(2) **Machining** of cavities is very satisfactory where the required depth is not too great. This method is frequently used in the production of dies for injection molding. A striking demonstration of the size and complexity of the dies that have been produced by machining was Mr. Faber's exhibit of an acetate molding of the pieces for three wagons making up part of the new 20 Mule Team Borax premium. All of the pieces for the three wagons were molded in one shot in a 104-cavity mold.

(3) **Ultrasonic abrasion** is a relatively new process which seems to offer interesting possibilities for the production of shallow cavities having much detail but no undercuts. A soft medallion made of copper, brass or aluminum is coated with abrasive and placed on the hardened matrix in which the cavity is to be formed. The medallion is vibrated at ultra-sonic frequency by a specially designed machine, so that the matrix receives some 20,000 impacts per second. This extremely rapid vibration sinks the medallion into the matrix in a short time.

(4) **Electroplating** with a nickel-cobalt alloy is another recently introduced process for making cavities. This method will accurately reproduce surface textures and fine detail, can be used for making cavities with deep and narrow slots, and permits the production of several cavities in a small area. The main disadvantage at the present time is cost, the speaker said.

(5) Casting of dies by various methods has been in use for some time. The centrifugal casting of stainless steel will produce very satisfactory dies if close tolerances are not required. Hard cast iron dies, on the other hand, may be produced to close tolerances, but fine detail is not possible. Such dies cannot, of course, be used for vinyl molding, because of the corrosion problem. Beryllium pressure hobbing produces excellent dies which may be held to quite close tolerances, although as in all hobbing work, there is some danger that the hob will distort under the pressure used. In this process molten beryllium (at about 2200°F.) is poured into a ring, and when the metal has cooled to about 1900°F., the hob is set in under moderate pressure.

Newark

Nylon Uses and Material Choice Provide Interesting Discussions

Robert Bostwick

The regular February meeting of the Newark Section took place on February 9 at the Military Park Hotel. Approximately 100 members and guests attended the dinner and heard two fine talks, followed by a spirited discussion.

Those attending were welcomed by the new president, Bill Willert, who introduced Pete Simmons, our National Director. Pete reported that for the first time in many years the Newark Section was not first in membership. He urged renewed activity on everybody's part and support of our new Membership Chairman, Frank Quinby. The meeting was then turned over to Milt Sanders, our Program Chairman.

The first speaker was Mr. W. C. Wall, Supervisor of du Pont's Nylon Products Development Dept. Mr. Wall discussed recent developments in nylon and illustrated his talk with a large collection of slides. Du Pont supplies nylon as powder, monofil, and bristles. Another basic form is extruded rod for machining of models or test pieces.

Mr. Wall dwelt largely on the mechanical applications of molded nylon. An early application was as a bearing for baby carriages. Nylon is useful in anti-friction bearings. In a particular helicopter part, nylon increased service life from 25 hours to at least 1,000 hours. In both bearings and gears, nylon can be used without lubrication. This makes it useful in such diverse fields as textile machinery, refrigerators, and elevator rails; also airplane instruments where thickening of grease at low temperatures creates problems.

In a succession of slides, Mr. Wall showed nylon parts in the automotive industry and business machines. Because it is sterilizable, nylon is used in medical instruments. An interesting slide showed 54 nylon parts in a new fare counter for buses.

Mr. Wall revealed that a fundamental study of non-metallic gears has been under way at du Pont and also at the University of Michigan. He predicted that basic engineering information would be available soon from these studies. Effect of environmental conditions on nylon gears was included in the studies. Also under way has been a study of the molding process itself, as related to nylon.

An interesting side aspect of Mr. Wall's talk was that he used an automatic slide projector, which changed slides by a control from the speaker's rostrum.

The second speaker was Mr. J. H. Du Bois, Vice President of Engineering, Mycalex Corp. of America. Mr. Du Bois prefaced his talk on "Material Selection Considerations" by stressing the part strong technical programs have played in the growth of SPE.

Mr. Du Bois pointed out that there are a great many characteristics to be considered in making the proper choice of a plastic. The special properties of the plastics have greatest value when they are efficiently used in the overall product design. For example, in electrical applications, materials are available for each type of problem such as for high voltages, high frequencies, high current arcs, semi-conductors, permeability cores, anti-static capacitors, high and low temperature, and corona insulation stability. There are special chemical resistance properties, "feel" characteristics, colors and textures, and thermal properties.

The importance of comprehensive information in avoiding pitfalls was discussed. A striking example mentioned was the ordinary electric iron handle where a phenolic compound of high heat resistance might be unsuitable because of too high a thermal conductivity. There are requirements which tend to narrow the field of choice considerably, such as elasticity, high and low temperature performance, arc resistance, radiation resistance, color requirements, transparency and dimensional stability.

With regard to the last item, it was pointed out that there is no organic plastic possessing "total" dimensional stability, and glass-bonded mica is the only material suitable for precision products with such a requirement.

Mr. Du Bois concluded his talk with the observation that as regards cost, the wrong material is always the most costly.

Among the subjects raised during the discussion period was the use of fillers in nylon. Mr. Wall pointed out that fillers tend to separate in the melt and cannot be used.

Door prizes were donated by Lionel Corp., Industrial Synthetics, Newark Die and Natvar Corp. Don Biklen brought up the matter of the annual June outing and those present voted in favor of a clambake.

The next regular meeting on March 9 featured a panel discussion on "Forming Themoplastic Sheet." Moderator was Mr. R. Carter of Celanese Corp. Panel members were J. W. Mighton of Dow, S. Zimmerman of Vacuum Forming Corp., and F. Quinby of Celanese.

Southern

Use of Acrylics Is Described

C. Veazey LeCraw

The Southern Section had as its speaker for the February meeting Mr. Robert Dawson of the Rohm & Haas Design Laboratory in Bristol, Penn. The subject of his talk was "Acrylic Plastics".

Mr. Dawson discussed briefly the physical and chemical properties of acrylics which makes this material such a useful tool in the hands of a designer. He discussed at length the optical properties of acrylics and showed examples of parts illustrating methods of piping, bending, and reflecting light to accomplish a desired effect. Development of many of these parts was carried on in the Rohm & Haas Design Laboratory by Mr. Dawson and the Rohm & Haas staff. Parts illustrated included lenses, dials, edge lighted panels, horn buttons, nameplates, and various decorative items.

Newark Officers And Directors

Bottom Row, l. to r.: Bob Hoehn, Secretary; Don Biklen, vice president; Bill Willert, president; Joe Bonnano, past president.
Middle Row, l. to r.: Pete Simmons, national director; Bob Bartlett, director; Ed Soules, director; John Lombardi, director.
Back Row, l. to r.: Islyn Thomas, past national director; Art Lange, director; Dick Goldrick, director; Wayne Schrag, director.

Southeastern Ohio

Tour of Cambridge Panelyte Plant Illustrates Injection Molding Processes

William J. Stranathan

The Southeastern Ohio Section of the S.P.E. had forty-one members and guests present at the January meeting, which was held at the Berwick Hotel, Cambridge, Ohio.

The new officers as follows took their office. President, Ray Baker of Fabri-Form Co., Byesville; Vice President, Sam Kline of Contintental Can Co., Newark; Secretary, Lester M. Dickson of Cambridge Tool and Die Co.; Treasurer, Fred Burkhardt of Fabri-Form Co., Byesville, Ohio.

The president announced that the directors are: Don Frazzoni, Fabriform Co., Wm. J. Stranathan, Cambridge Tool and Die Co., Sam Kline, Continental Can Co.

A formal invitation was read from the Ohio Secretary of Professional Engineers asking our Section to meet with them February 22 at the Winsor Steak House, Zanesville, Route 22 west.

Dr. Brown of Dover will speak on the theory of Flying Saucers.

National Director, John Chomicz of General Electric Co., Coshocton, Ohio gave a report of the convention at Atlantic City, and stated that a proposed program for developing a Professional Engineers class for the Plastics Engineers was discussed and passed by the National Board of Directors. He also stated that more thought be given to Local Technical and Educational Committees.

The meeting was then turned over to the program chairman, Paul Brill of Cambridge Panelyte Molded Plastics Co. The feature for the evening was a complete tour of the Cambridge Panelyte Co. Mr. Brill stated before leaving for the tour that the Company was formed in 1946 by Eli Jenson, C. R. Downs, Paul Osterberg, Mike Orakoske. In 1953 it was bought by the Panelyte Division of the St. Regis Paper Corp.

The Company is one of the biggest molders of refrigeration parts in the country and also does work in the aircraft, automotive, and small applance field. They operate plants in Cambridge, Ohio and Richmond, Indiana. Their Cambridge plant houses nineteen injection presses ranging from three ounce to one hundred and twenty ounce and the Richmond plant houses eight injection presses, ranging from twelve ounce to one hundred and twenty ounce.

As the tour progressed many different problems in molding were discussed and articles were presented for examination.

Eastern New England

Plastics Scholarship at Lowell Institute Provided by SPE Section

Alfred I. Simon

The Society of Plastics Engineers awards first scholarship in plastics engineering to Lowell Technological Institute! This scholarship will cover a full year's tuition for a deserving student.

The ever increasing demand by industry for trained plastics engineers came to the attention of the leaders and planners of the progressive Lowell Technological Institute. As a result, a full four year day course has been initiated, at the completion of which, a student will receive a bachelor of engineering degree in plastics.

The educational activities of the Society of Plastics Engineers, Eastern New England Section, is presently engaged in attempting to make known to the various educational institutions the increasing need and demand for engineers trained in plastics. This program today has been one of attempting to interest institutions in considering plastic programs and secondly, to make high school students aware of the future awaiting them should they select plastics engineering as a career.

The new officers of the Eastern New England Section are: president, Harry Connors, B. F. Goodrich Chemical Company; vice president, Robert Davenport, Gregstrom Corporation; secretary, Josiah Crosby, Hood Rubber Company; treasurer, Ralph L. Mondano, Raytheon Manufacturing Company; and national director, Richard Beckwith, Dow Chemical Company.

The Section directors are as follows: (three year terms) Albert Dietz, Massachusetts Institute of Technology; R. Moen Smith, Bolta Products Company; and David Towler, M. W. Kellogg Company; (two year terms) Josiah Crosby; Ralph L. Mondano; and Fred Quarterone, Bolta Products Company; (one year term) Richard Beckwith; Harry Connors; and William Root, Raytheon Manufacturing Company.

The Committee chairmen include: credentials, Fred Quarterone; membership, Joseph Clancy, Emery Industries, Inc.; educational and professional activities, Ralph L. Mondano; program, David Towler; publicity and S.P.E. Journal reporter, Alfred I. Simon, Raytheon Manufacturing Company.

Joint meetings with the Society of Plastics Industry are held on the third Thursday of each month after a 7:30 P.M. dinner at the Hotel Beaconsfield, Brookline, Massachusetts. These meetings are alternately sponsored by the S.P.E. and S.P.I. Technical speakers as well as speakers from other phases of the plastics industry present timely talks and technical presentations.

Connecticut

Automatic Molding Progress Outlined

David Mersey

The February meeting of the Conn. Section was held on the 11th at Bridgeport, with a turnout of 45 members. The program was presented by the F. J. Stokes Co., whose Mr. Quentin White ably presented a talk on 'Automatic Molding'. This was presented as being indicative of a trend toward more and more automation in the fields of compression and injection molding.

The first portion of the talk was spent on a description of the automatic compression press, which, incidently, grew out of a need for a small press which could be operated at small labor and tool costs, and still be a profitable operation. From this modest beginning, this mechanism has developed from a single cavity model to multi-cavity units equipped with automatic side-draw and thread-stripping actions. Too, the newer models can accommodate small or large nodule materials, whereas, in the not too distant past some molders specified 'Stokes granulation' from their powder suppliers.

The four ounce injection model is a horizontal, straight ram, hydraulic clamping, press. Except for feeding compound pellets into the hopper, it is fully automatic. It gives positive ejection, and delivers finished degated pieces, which require no further finishing. The molded pieces and runners are removed from the knockout pins by mechanically operated combs, and runners are fully detached from the molded pieces.

Labor costs are reduced by as much as 90%, so that labor ceases to be a significant factor as a manufacturing cost, and the molder is no longer forced into making a compromise decision between labor and tool costs. As in the compression press, one person can maintain ten presses.

Once cycled, all operations fall into regular sequence, so that no damage can be done to the machine or molded parts. If any interruption should occur, the press will stop automatically so that the condition can be corrected and the press restarted. No reliance is placed on air ejection.

R. I. and S. E. Mass.

Jim Underwood Reports on National

Stephen Kalarian

A congenial group of twenty eight SPE members met in January at the Crown Hotel to greet the executive secretary from the National Office, Jim Underwood.

Mr. Underwood having just returned from the Technical Conference in Atlantic City briefed the section on some of the highlights of this annual affair. Registration for the conference was 1665, an all time high. The three concurrent sessions had fifty nine papers presented with an average attendance per session of 400 people. The evening banquet with Brig. Gen. C. J. Bondley, Jr. as principal speaker had an attendance of 700 people.

The growth in the national SPE is reflected by the number of members as of December 31, 1954—3,700 members in the United States and Canada. The society now points with pride to thirty two (32) sections in its realm. Our own section — Rhode Island and South Eastern Massachusetts Section —is the thirteenth (13th) largest section and is only ten (10) members shy from being in twelfth (12th) place. The New York section, as might be expected, is the largest of all sections.

Mr. Underwood also informed the section that several states have now under consideration proposals to inaugurate the issuing of licenses to plastic engineers. At present there are sixteen (16) states that do issue such documents. The National organization has announced that henceforth a plastics engineer will be defined as follows:

"An engineer mainly concerned with the application of principles of engineering and allied science to the production or utilization of plastics materials."

Co-guest speaker for the evening was Mr. Albert McIntyre of Reed-Prentice Co. He gave the group a lucid description of their new 175 ton four ounce injection machine. Salient features of this machine are as follows:

a. Dry run speed is six seconds per cycle

b. 22x24½ die platens

c. Eight inch stroke

d. Hydraulic unit knocks nozzle away from sprue bushing

e. 220 volts heating; 110 volts controls.

f. Improved safety features.

Before closing Mr. McIntyre gave a cordial and sincere invitation to SPE members to visit the Reed-Prentice factory at any time.

Detroit

Expansions Feature Area Growth

Mac Nichols

Expansion programs of considerable proportion have been completed by many companies in the plastic group of the Detroit Section, as the greatest movement in years has found a large number of plastic processors occupying newer and larger quarters, to better serve customers in the industry.

Helmut Blossey, Manager of All State Industries, has added new machinery to augment his present equipment in their new plant at 25101 Mound Road in Centerline. The new brick building has 4000 square feet of floor space and is equipped to handle diecast dies and plastic molds.

The Detroit Plastic Products Company moved into their new building at 35135 Groesbeck Highway, Mt. Clemens on March 1st, bringing under one roof all of the facilities of the company. The addition of a new 4 oz. Reed-Prentice brings their total of injection molding presses up to seven, with ample room for additional equipment in their spacious 12,000 square foot building.

Pat Luckino, Owner of Luckino Die & Engraving Company has projected his plans for expansion by moving into the 4000 square foot building at 21614 Groesbeck Highway, East Detroit, recently vacated by the Detroit Plastic Products Company. By this move, Mr. Luckino has doubled his capacity for all phases of plastic fabrication including designing, mold building and custom injection molding from 4 oz. to 12 oz.

Raymond Mold Corporation have outgrown their former quarters and are now occupying a 3400 square foot building at 11080 East Nine Mile Road in Van Dyke. President Loren Raymond has added several new machines to his shop equipment to augment the present fixtures.

Jim Mallendine of Michigan Molds, Inc., recently announced not only the arrival of a new addition to his family, but also the expansion of his company by a move into the building at 25812 John R. Road in Royal Oak, formerly occupied by Lenco Die & Engineering Company. His corporation has also added several additional machines to their plant to broaden the scope of their plastic mold fabrication.

We understand that expansion programs of a similar nature are being contemplated by several other members in the Detroit Chapter, tending to emphasize that the designation "Dynamic Detroit" is well justified.

Southern California

Felix C. Karas

The Society of Plastics Engineers held its regular dinner meeting on Thursday, March 3, 1955, at Scully's Restaurant, 48th and Crenshaw Boulevard, Los Angeles, California.

Mr. Clarence Howard of W. S. Shamban & Company, Culver City, California, spoke on Fluorocarbons—Resins for Extremes.

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You may ask "Why worry about the overall progress of plastics?" I give you the simple reason that a minister gave our young people's meeting several years ago. It was, "you cannot raise the level of those around you without raising your own level at the same time." Let's each do what we can to assure progress in raising the level of the Plastics Engineer.

Yours for better living with Plastics

Wayne I. Pribble

Runnerless Molding . . .

(continued from page 29)

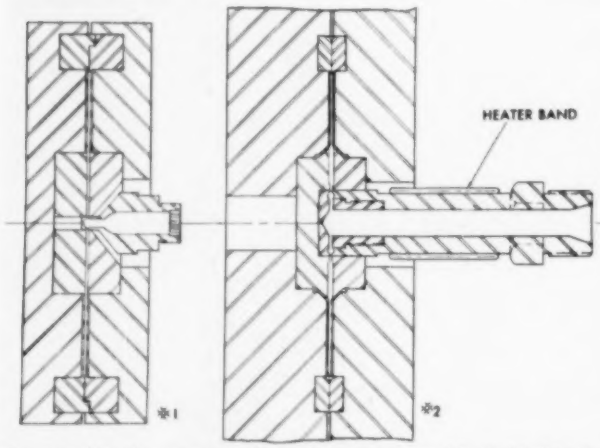
construction, the mold operated very successfully. As you will note, the hot runner plate is isolated from the back of the mold and from the cavity plate. Water cooling was passed directly through the mold on either side of the nozzles. This is good, successful hot runner mold design.

Drawing 10 illustrates a different conception of hot runner molding. Shown, is a cross-section of a 10-cavity golf tee mold. A small square bar is fastened to the stationary half of the mold. An air gap is provided on both halves of the mold to prevent excessive heat transfer. Nozzle plates are installed into the hot runner bar with 3/16" square nozzles coming in direct contact with the cavity plates. The cavity blocks themselves are water cooled. The runner bar is heated with cartridge heaters. Temperature is maintained. The bars and blocks of steel, that form the end of the golf tee are on the movable side of the mold. When the mold opens, the bars actually lock the golf tee into the movable half of the mold and shear the gates. As the platen completes its travel, these bars engage the knockout rods and are moved forward, removing the parts entirely from the cavity. An air blast will free the golf tees from any suction to the balls and the parts are free to fall. We have actually built a mold of this construction. Its operation, however, was only fair, due to the fact that the runner bar was too small. From the experiments we have run, we know that, with good mold engineering, this type of mold construction can be entirely satisfactory.

Production of Phonograph Records with a Runnerless Method

In studying the art of injection molding of records, we have found that it has been necessary to heat mold platens to a temperature of approximately 150° to 160°. This temperature is very near the softening point of the styrene record compound. Under the circumstances, cycle time is rather long and the records must be cooled externally from the mold.

Normally, a nozzle is used with a hole the size of the center hole in the record, of approximately .286" in diameter. The injection is made from this large nozzle opening through a passage of this diameter into the actual record cavity. After the passage and cavity have been filled with plastic and pressure has been held for a sufficient length of time to set the record, a punch is actuated from the movable platen side of the mold. This pierces a hole through the record, of spindle size or approximately .286" in diameter. This punch not only pierces the hole, but it continues in its movement until the entire slug is moved back into the injection nozzle. This material must then be re-heated to be used for the next cycle. It is my belief that it is a physical impossibility to heat this slug in approximately 30 seconds. So, under the circumstances it must be re-heated by the passage of hot plastic from the material cylinder on its way to produce the next record. For this reason, I believe it is necessary to maintain a very high mold temperature to mold finished records successfully.



Drawing 11. Two cross-sections of a record mold, (left) Nozzle is used as a core. (Right) Two-piece nozzle. The mold on the right is more successful.

The following is a description of a direct runnerless injection method.

Drawing 11 shows two cross-sections of a hypothetical phonograph record mold. Cross-section No. 1 shows a 7-inch diameter record complete in the mold, with a standard spindle hole. The point that we would like to discuss is the nozzle construction. As you will note, this nozzle is actually used as a core and forms the hole in the record. Plastic is sent through the core, or nozzle, through a group of very tiny holes to form the record. The machine or mold is so arranged, that as the clamp opens, the entire mold moves away from the nozzle, stripping the record from the nozzle. After the mold has moved approximately ⅜", it then opens, the record is held in the movable half of the mold, and is ultimately ejected.

Cross-section No. 2 shows slightly different nozzle construction for the 7" 45 RPM records. In this particular case, the hole through the record is approximately 1½" in diameter. For this mold, a two-piece nozzle has been constructed as illustrated. An opening .010" wide is provided completely around this 1½" diameter nozzle. Plastic is forced through this slight opening, filling the cavity, and, as described above, the mold is opened, the rear platen moves to strip the mold from the nozzle, the rear platen continues to travel to the knockout rod, and the record is ejected.

Records have been very successfully molded with the above-described method, in molds having a temperature from 90° to 130° on cycles as rapid as 12 seconds. Records made with this method are ready to label as they leave the mold. No secondary cooling is necessary. Records molded with the originally-described method must be held between cool platens or cooled after they leave the mold cavity.

Under no circumstances have we tried to give you exacting mold design in this presentation. Through research, and through development by trial and error, the above-described experiments have been successfully proved on our automatic molding machines. It is my thought that additional profits can be made by giving very careful consideration to mold design, in order that both sprues and runners can be eliminated. It is my hope that this paper has given you food for thought, and, if I have solved the problem for any one molder in the industry, my time has been well spent.

(Reference 1. Modern Plastics Magazine, June 1952)

Process Capability Analysis . . .

(Continued from page 22)

variabilities to this total. The Pictogram of Figure 5 indicates that the Total Span ($6\sigma sp$) is about .0105". This is determined by noting that the distance between the Lower Process Limit (LPL) and the Upper Process Limit (UPL) is 10.5 on the scale (i.e., 31 to 41.5). The pictogram also indicates that practically all of this variability is contained within the lot, since the within-lot leg of the

(Please turn to page 38)

THE *Injection* MOLDERSCOPE

By A. R. Morse

President, Injection Molder's Supply Co.

"It is the freedom to disagree, to quarrel with authority, in intellectual matters to think otherwise, that has made this nation what it is today." Dr. James B. Conant

NOZZLE BAND CONTROL

The typical injection machine heating cylinder has a 3½" or 4" or some small diameter front heater band with 300-750 watts heat. Usually, this band is connected to the front group of bands or into the front control circuit. On some machines, a 3 spot switch is used. On old machines prior to 1942, a rheostat was used. Recent experience, especially with the growing use of heated extension nozzles, indicates that this front band should have a stepless control like the Variac used to give closer control, than previous methods. In many cases, the front group of bands do not go on at all, or only at long intervals, so the reason for separate control of this band should be obvious. The small investment required, (about $41.00,) is quickly offset by molding improvement so it will clearly pay off to revive this front band to its own control. Use of the control allows you to regulate drooling, stringing, or burning of the sprue tip, facilitates startups, and reduces sprue sticking. It is a neat time saver for any molder.

STEPLESS CONTROL

It has not been done to date, but I would like to see a heater where every band is individually controlled by its own Powerstat or Variac. The thermocouples would then be used to give heat readings only, not to control the heat, and we could get any kind of a temperature curve needed. As it is, with all due regard to the efficiency of modern pyrometer controllers, when they call for heat, you get an awful load of it, and if we had each band on its own controller, we could eliminate the surges we now get. This idea would also eliminate contactors and simplify wiring, and of course provide a great saving in pyrometer costs. The wiring would last longer since it would not be overloaded as it is at present. It would, however, give you a battery of Variacs or Powerstats that would look like an organ console. Apart from that, I believe that if it were up to me to specify controllers for a press, I would take a flier on stepless, continuous, individually variable heater band controls. This is not a new idea, but one that I believe would give much improved heater performance over the best that any pyrometer could do, mainly because band grouping is eliminated—and who knows how bands should be grouped.

USED INJECTION MACHINES

Used injection machines now being offered are setting an unusual high for ASKED prices. Once in a while a sale is taking place, but unless the emergency is great, results obtainable from older presses cannot justify present asked prices.

Injection molders must realize that obsolescence has finally taken its toll, and that they can no longer expect to buy a new machine in 1946 for $9000, use it for several years, and then sell it for the same price that they paid for it! This fantastic situation actually persisted up to the early summer of 1953, but it no longer prevails for two reasons. First, new machines are now in ready supply; and second, they have been greatly enlarged and improved under the impetus of a competitive condition which became apparent in late 1953.

While it often pays to increase the plasticising capacity of an older press (and this can easily be done at moderate cost), still you cannot increase platen size, and it is in increased platen area that the biggest changes have taken place. Heating cylinders from 60 oz. machines are now seen on 16 oz. presses indicating how plasticizing capacity has been increased (and why preplasticizing is so slow in gaining ground). Manifolding of hydraulic systems has greatly simplified maintenance, and speeds have generally been stepped up. All these changes have resulted in prices of new presses continually climbing, and at the same time have acted to depress prices of older machines.

I therefore look for considerable downward adjustment in prices of used injection machines this year as molders begin to realize that the times have really changed at last.

Around the World

(Continued from page 30)

excellent mechanical, thermal, electric and chemical properties. The low pressure and the short cycles required for molding of Keripol, which does not have to be preheated at all, compare favorably with other phenolic molding compounds. The molding technique is thoroughly discussed and examples for application listed.

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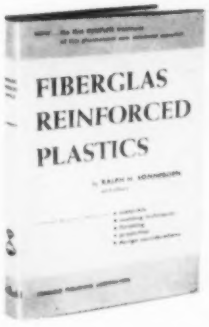
Edited by RALPH H. SONNEBORN



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Process Capability Analysis . . .

(continued from page 36)

right triangle is almost the same length as the Total Span.

The conclusion from the Stage I analysis, therefore, is that lot-to-lot variability is nil and that it is necessary to dissect the within-lot variability to discover a source of variation whose elimination would reduce the Total Span. This called for a Stage II analysis, in which six dispensers were chosen at random from a day's production of each cavity of the mold. (Two cavities were blocked off, so only 8 could be sampled.) These were measured in the same way and the Span Plan computations performed, as shown in Figure 6. This time, the pictogram reveals that cavity-to-cavity differences are a major contributor to within-lot variability. The within-lot span is about .012" (from 30 to 42 on the scale) whereas the within-cavity is only .008" as shown by the within-cavity leg of the two triangles. This means that, if the cavity differences were removed, the process could meet a tolerance of .008" (.234" to .242" for example), since only the within-cavity differences would remain.

This is still not sufficient reduction to meet the customer's original specification of .238" to .242", nor even his modified specification of .236" to .242", and the Span Plan calls for a continuation of the dissection to locate further candidates for reduction. However, at this point the molder felt that he had sufficient evidence to re-approach the customer, promising to eliminate the cavity differences and asking for approval of .234" to .242" tolerances. Meantime the customer, having re-evaluated his needs and faced with the factual analysis, was able to accede to this proposal.

SUMMARY

This article has attempted to present the basic concepts of the analysis of Process Capability and to illustrate several methods of performing such an analysis. In a simple case where only the effects associate with **time** need be considered, the use of the **X** and **R** chart plus the frequency distribution are sufficient to diagnose the problem. Wherever stream-to-stream, within-piece or error of measurement factors are or may be present, it is preferable to use the Multi-Vari chart, the Analysis of Variance, or the Span Plan. Of these, the Span Plan is probably the most universally applicable because of its judicious combination of adequate precision, ease of use and simplicity of interpretation of results.

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Friction of TEFLON . . .

(continued from page 14)

term" which deals with work of deformation of the plastic sheets.

The value of μ for polyethylene is given for comparison. Our results compare with other values as follows:

	Our Values	Shooter's Values (2a) *(hemisphere)*	Bowers' Values
Polytetrafluoroethylene	0.016	0.10 (steel)	0.10-0.04 (bulk)
		0.04 (plastic)	0.04 (film)
Polyethylene	0.09	0.2 (steel)	0.33-0.25 (bulk)
		0.15 (plastic)	0.05 (film)

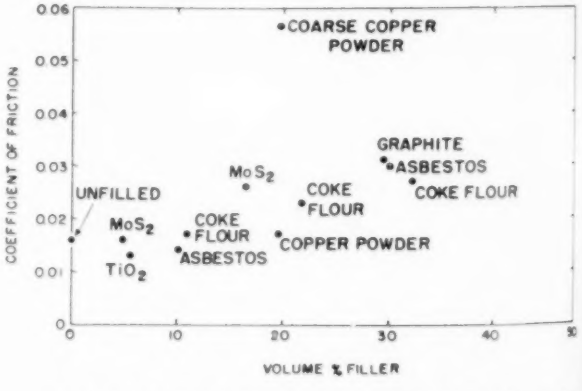
*Static and kinetic coefficients, steel on abraded polymer.

Bowers' values labelled "bulk" and "film" represent an experimental test of Shooter's relation between shear strength, yield pressure, and μ for polymers:

$$\mu = \text{shear strength/yield pressure}$$

Bowers altered the yield pressure of polymers by depositing them as a thin film on a relatively nonyielding steel plate and found that μ varied accordingly, although the picture was complicated by transfer of polymer to steel during the experiments. Our apparatus, in which no further compression of the polymer takes place during the measurement of μ, may well give values which represent the limiting case of Shooter's relation. In our experiments it must be remembered, however, that measured values of the coefficient of friction are very sensitive to the surface finish of the steel against which the friction is measured. We found, for example, a value of 0.035 for μ of unfilled "Teflon" against the steel ring finished with #600 Carborundum in a lathe before being micropolished, compared to 0.016 after micropolishing. Because of the effect of surface finish Shooter's, Bowers' and our results may not be strictly comparable. Our low values obtained with the micropolished ring may thus be due to its surface finish or, as suggested above, the low values may represent the limiting case of Shooter's relation.

FIGURE 3. Coefficient of Friction Depends on Filler.



As for the filled compositions, Figure 3 shows that μ is more dependent on the amount than the type of filler. In fact, it is very likely that the type of filler does not affect results within the experimental error. The high coefficient shown for "Teflon" filled with coarse (80 mesh) copper powder emphasizes that in extreme cases the nature of the filler particles can grossly affect the results.

The coefficient of friction of unfilled "Teflon" was found to be constant at 0.016 in the temperature range 25 to 300°C. Values could not be measured at temperatures higher than about 305°C. due to plastic flow of the sample at the high normal forces used.

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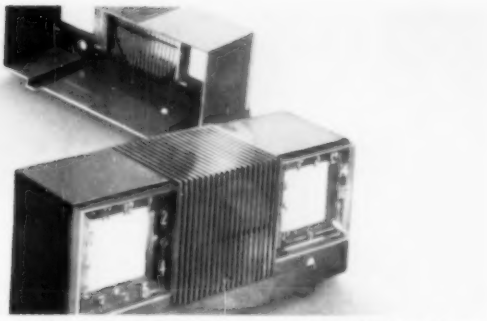
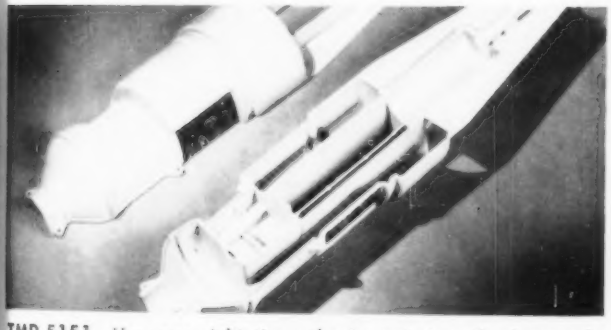
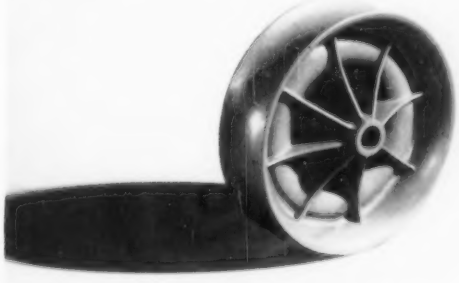


SMD-3000—Its high heat distortion point measures 197 deg. F. on unannealed test bar ¼ in. thick. Other advantages: reduced molding pressures, better mold release, and faster cycles. It completely eliminated warping and distortion in molding these radio cabinets. Notice their fine details, glossy surfaces.

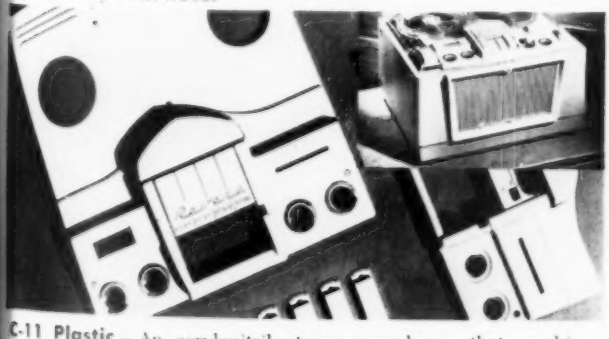
SMD-3500—A general-purpose styrene whose high plasticity and fast set-up permitted one manufacturer a 50 per cent cut in molding cycle time. Another reduced cylinder temperature by 50 deg. F. Equally serviceable for moldings such as big crisper drawer or the close-fitting syringe holder parts shown.



TMD-5151—Has over eight times the impact strength of general-purpose styrenes*. High plasticity results in fastest set-up speed for a high-impact styrene. Surface gloss is outstanding, color range unlimited. These toy vacuum cleaner parts show intricate mold details reproduced by TMD-5151.



TMD-2155—Has about eighteen times the impact strength of general-purpose styrenes*. Stays tough down to —13 deg. F. Has high heat distortion point, superior surface gloss, and excellent color. Economy, color, and strength are features of this lawn mower wheel molded of TMD-2155.



C-11 Plastic—An acrylonitrile-styrene copolymer that combines toughness with rigidity, color and gloss. Withstands food acids and oils, gasoline, moth balls, soaps, detergents, carbon tetrachloride. C-11 parts in tape recorder shown provide durability and fine appearance.

BAKELITE
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*ASTM average Izod test values using notched ⅛ in. bar at 74 deg. F.

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FOR TOYS ON THE MOVE...

BUCKY BURRO—Hercocel acetate ears flip back and forth; spring tail swishes as burro bucks up and down with realistic kicking motion; life-like "hee-haw, hee-haw" sound intrigues every child.

DONALD DUCK—Hercocel acetate feet revolve with laughable "flip-flop" action on this most realistic Donald Duck in pull toy history; ingenious voice mechanism sounds just like Donald himself; arms swing in unison with feet and legs. Both toys manufactured by Fisher-Price Toys, Inc., East Aurora, New York. Hercocel parts molded by Trimold, Inc., Kenmore, New York.

Two of the newest and most ingenious pull toys to come off the Fisher-Price production line, this Donald Duck and Bucky Burro promise new counter appeal and profits for smart retailers. A clever combination of lithographed wood and super-tough Hercocel plastic, they've got color . . . action . . . sound . . . and the durability that keeps both children and their parents happy.

There's greater play value and longer play life in toys when parts are molded from Hercocel—Hercules® cellulose acetate, a safe and enduring plastic. And manufacturers find that Hercocel's toughness cuts losses in assembly, shipment, and display. From plant to purchaser, Hercocel truly *keeps toys on the move.*

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